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Journal of the Society of Arts.

FRIDAY, MARCH 9, 1855.

THIRTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 7, 1855.

The Thirteenth Ordinary Meeting of the One Hundred and First Session, was held on Wednesday evening, the 7th inst., Colonel Challoner, in the Chair.

The following Candidates were balloted for and duly elected Ordinary Members:—

Armison, George	Lermit, Rev. Gerald
Colman, Jeremiah	Rogers, Ebenezer
Dickins, Thomas	Spark, Henry King
Gibson, Ths. Field, F.G.S.	Vavasseur, James
Jaffray, Richard	Wooldridge, J. W.

The Paper read was

ON THE SEWAGE OF LONDON.

By J. B. LAWES, F.R.S., F.C.S.

Whoever undertakes to bring forward plans for the economical disposal of the sewage of the metropolis, is at once met by the difficulty arising from the enormous bulk of the material with which he has to deal. It is estimated, that between one and two hundred million tons of fluid pass through the sewers annually; and it is said, that solid matter amounting to nearly 200,000 tons, is suspended or dissolved in this liquid. Those who advocate the employment of the sewage by irrigation, must therefore seek for an extensive tract of land at no great distance from London on which to deposit this fluid; whilst those who propose to separate from it a solid manure, must produce a substance of sufficient productive value to bear the cost of carriage to all parts of Great Britain. Of late years much money has been uselessly expended in patents and inventions for converting the sewage into a portable manure, which might have been saved by a better knowledge of the true principles of manuring, and the wants of agriculture. The authors of these inventions, considering that farmers are willing to pay £10 or £12 per ton for foreign guano, are surprised to find that their British substitute is in no demand at one quarter the price; and they are inclined to tax the farmer with ignorance in the management of his business, and with prejudice in favour of a foreign commodity. It may safely be asserted, that agriculturists not only have no prejudice in favour of foreign manures, but that they would be only too glad to find some substitute which they could employ with advantage. They are, however, fast learning by experience, that a low-priced manure is not necessarily a cheap one. The question they are beginning to ask, is—*not* what is the price *per ton*, of this or that manure? But, in what manure can I most cheaply bring upon my land certain constituents which I require? The inability to answer this question satisfactorily has hitherto brought all the producers of sewage manure to a stand-still. Those who in future propose to deal in this manner with sewage, should consider well this question. The success or failure of their inventions will infallibly depend upon the answer they can give.

It should never be forgotten that it is the cost of carriage which regulates in a great measure the distribution of manures, and assigns to each a limit of area, beyond which it cannot profitably be employed. No one doubts the value of stable manure; yet its use is confined to a range which does not exceed a few shillings per ton for carriage; and a farmer who would have to cart it beyond

this range would not accept it as a gift; and it is for a similar reason, that even, supposing the manufacture of a solid manure from the sewage of a small town could be carried on with profit, it might still be quite impracticable as applied to London. The local demand in the immediate neighbourhood of a small town, might, perhaps, absorb the whole supply, whilst the vast produce of the London sewage could only be disposed of by a general sale all over the country.

The term *manure* includes a great variety of substances, from the disgusting mass of corruption, the very idea of which is almost sickening, to the purest and most delicate crystallised salts. It is not one of the least of the many beautiful and economical arrangements which we see around us whereby the Almighty has endowed the same particles of matter with the property of entering into a variety of forms, at one time the most offensive, and at another the most attractive. In this ever changing circle, nothing is without its value, nothing is lost. Whilst, therefore, all matters in one sense waste and refuse, have their absolute value when considered in a scientific point of view, they have at the same time another and an independent value as articles of commerce; and to assign to each its proper money equivalent is a most important office of scientific and economic agriculture.

The crops grown by the farmer are found to be composed of a number of different elements; and if the soil were only a medium of support to the roots of the plants, and neither it nor the atmosphere furnished any of these elements, the art of manuring would be simple enough; it would be confined to replacing the elements contained in the crop exactly in the proportion in which they were removed from the land. It happens, however, that a certain portion of each of the elements which the plants produced contain, are furnished either by the normal soil or by the atmosphere, but some of them not in sufficient quantity for agricultural purposes. True economy in manuring consists, then, in adding those substances to the land of which the supplies of the soil and atmosphere will be deficient. In order to ascertain experimentally which of the various constituents of our agricultural plants it is most important to supply by manures, it is necessary to grow each particular crop for a series of years with different manurial mixtures, in some cases supplying the various constituents separately, and in others with two or more of them combined together. By following this course, and carefully weighing the produce obtained, a knowledge is by degrees acquired of the relative value and importance in a manure of the different ingredients. In illustration of the usefulness of this kind of inquiry, I propose to refer you to a few experiments of the sort in question, which have been conducted by myself on the wheat crop. The results I have selected for this purpose, are those of the seasons 1844 and 1854. Between these periods there is an interval of nine years, during which the same kind of experiments have been going on upon the same plots of land; but as these intermediate results are all in the same direction as those of last year, and I do not wish to inflict upon you more of detail than is necessary to explain my subject, I shall omit all reference to them now.

TABLE I.

Selection from Experiments in which Wheat has been grown upon the same Land for 11 years in succession.

Plot Numbers.	Manures.	Bushels of Dressed Corn per Acre.		Straw per Acre in lbs.	
		1844	1854	1844	1854
2	14 tons farm-yard manure every year	22	41	1476	4543
7	Minerals in 1844, Minerals and Ammonia in 1854	16½	45½	1172	5603
8	ditto ditto ditto ditto	16½	47½	1160	6184
10	ditto ditto Ammonia only in 1854	16½	34½	1112	3597
16	Minerals, with 14 lbs. Ammonia, in 1844, with 180 lbs. in 1854	21½	50	1480	3424

If you will turn to Table I. (*vide* preceding page), you will see that Nos. 7 and 8, when in 1844 they were manured with mineral substances only (alkalies and phosphate of lime), they produced between 16 and 17 bushels of wheat per acre. In 1854, with the employment of similar minerals with salts of ammonia also, the produce of corn is nearly three-fold, namely, in one case, 45 bushels, and in the other 47. There is, moreover, about five times as much straw as in the former season.

The plot No. 10, which yielded nearly 17 bushels of corn in 1844 with mineral manures, produced twice as much grain in 1854, and about three-times as much straw. The remarkable fact connected with this experiment No. 10 is, that since the use of minerals on that plot in 1844, ten successive crops of wheat have been taken from the land, by the aid of salts of ammonia alone. Thus, during this period, a gross produce of about 20 tons has been obtained by no other addition than about 800lbs. of ammonia.

The plot No. 16, you will see, produced in 1844 twenty-one bushels of wheat, that is 4 or 5 bushels more than the plots with mineral manures alone, it having received in addition to minerals the small amount of 14lbs. of ammonia. In fact, this was one of the few plots manured with ammonia at all in that year. In 1854, this plot 16 had received besides minerals, 180lbs. of ammonia to the acre. This is the highest proportion of ammonia that has ever been used in the course of these experiments, and with the favourable season of 1854 it also yielded the largest crop—namely, 50 bushels of corn, and 6,634lbs., or nearly 3 tons of straw.

Plot No. 2 has been manured every season for the last eleven years at the rate of 14 tons farm-yard manure per acre—amounting in all to 154 tons. The produce on this plot is increased from 22 bushels in 1844, to 41 bushels in 1854; but even this latter amount is much below that yielded by the plots 7, 8, and 16. This experiment affords a striking illustration of the fact that *bulk* of manure does not constitute value. Thus, in the 154 tons of farm-yard manure, there has been placed upon the land a larger amount of all the ultimate constituents of corn and straw than the crops removed contained. On the other hand, if we were to apply the same sort of calculation to the crops grown by means of minerals and ammonia, or ammonia alone, we should find that a very few per cent. of the produce had been actually supplied in the manure. In the case of No. 10, in fact where ammonia salts alone have been used for many years, not more than 1½ per cent. of the increased produce was really derived from the manure which has yielded it.

In regard to these experiments as a whole, when I tell you that with the most favourable combinations of minerals, and under the most favourable circumstances of the season of 1854, not more than from 23 to 24 bushels of wheat was in any case obtained, it will be obvious to you that the whole of the difference between these amounts and 45, 47, and even 50 bushels, as in the cases given in the table, must be entirely attributable to the ammonia which was employed. And I may add, that as far as my experience goes, there is no substance known which can be substituted for ammonia or some other compound of nitrogen with like effects.

Farm-yard manure is estimated to contain about ⅓ a per cent. of this ammonia; or about eleven lbs. in a ton. It would therefore require about 17 tons of farm-yard manure to supply to the land the amount of ammonia used in the experiment No. 16. Now my farm is situated 25 miles from London, and being inconveniently situated for conveyance by railway or canal, the cost of carriage from London upon one ton of manure is 15 shillings. Therefore, if I were to bring my 180lbs. of ammonia from London in the form of dung, the carriage alone would amount to £12 15s. 0d. I could obtain the same amount of ammonia in ⅓ a ton of guano, or in 7 cwt. of sulphate of ammonia, at the cost of one half of the carriage alone of the dung. This example clearly shows, that it would

be cheaper for me to give £10 per ton for guano, or £14 per ton for sulphate of ammonia, than to have the dung as a gift. In the case of the guano and the salts of ammonia, pounds weight only of manure are brought upon the farm to produce tons of growth; in the other you bring tons to produce pounds. If time permitted, I could easily show, that with certain modifications the results obtained in the experimental growth of other cereal crops are in the main similar to those on wheat. And from such data, it is not difficult to decide the actual and relative values in a practical point of view, of the chief elements of manures. It will suffice to say, however, that whilst I consider ammonia is by far the most important and valuable constituent in an artificial manure, phosphoric acid is certainly the second in this respect. All my experiments lead to this conclusion; and it is, moreover, fully confirmed by the composition of all those manures in the market which have the most extended sale, and which are the most highly prized by the farmer. But no manure is entirely made up of ammonia and phosphoric acid, and the nature of the remaining ingredients has also to be considered in fixing a value upon the compound. It is, however, not necessary to dwell upon this point beyond saying, that when the chemical composition of any manure is known, there is no difficulty whatever in fixing the price at which it will eventually sell compared with other manures. And this would apply more particularly to any manure manufactured from sewage, as the quantity alone would bring it into competition with those already in the market.

Having now pointed out what constitutes *value* in manure, I will next direct attention to the composition of sewage. It will readily be admitted, that leaving out of the question the enormous bulk of water, the chief source of its valuable constituents must be the excrements of the population. There is indeed no means of estimating with any degree of accuracy the amount and value of the other matters. They are, however, decreasing every year; a necessary result of the increasing cleanliness of the metropolis, and of the more rigid sanitary measures which are being enforced. In fact, the chief additional matters that could be permanently calculated upon, are those which are derived from the grinding down and washings of the streets; and, however useful these may be, they would certainly not be worth much carriage in a portable manure; nor would they materially enhance its value.

Assuming then as we may do for all practical purposes, that the great bulk of the excrements of horses, cows, &c., in the metropolis, will not find its way into the sewers—that the refuse of manufactures valuable as manure which will do so, will be comparatively limited—and that the matters abraded from the streets with their small admixture of the excrements of horses and other animals, will also be of comparatively little value—we recur to *Human Excrements* as the main items to be taken into calculation.

The questions arise, then, upon what data can we fairly estimate the amount and the chemical composition of the excrements of the total population of London? In what condition of solidity or solubility will these constituents be found, and through what bulk of sewage will they be distributed? What would be the actual value of the constituents if separated from their admixture with water? And finally, what are the most promising means of turning these constituents to economical account, in the state of solution and dilution in which we find them?

It might, perhaps, appear at first sight, that the most feasible way of estimating what constituents enter the sewers, would be to analyse the sewer water itself; but when we come to consider the very small average proportion which the valuable ingredients bear to the bulk of the water, and also the necessary irregularity of their admixture with it at different times and places, this is found to be by no means the case. It must in fact be a synthetic, rather than an analytic method, by which we

must determine the constituents of Human Excrements which can be calculated upon in the sewer water.

A perfect knowledge of the average amount of solid and liquid excrements voided per diem, or per annum, by each individual of a large population—and of the composition of these excrements—would suffice to this end; and there does, in point of fact, exist much more of recorded information bearing upon this subject, than perhaps would be supposed. This evidence is collected in Table IV., to which I shall refer again further on. Since, however, we know that the constituents of the food taken into the animal body, all reappear either in the increase of the body itself—in the solid and liquid excrements, or in the exhalations by the lungs and skin—it would obviously be a very important confirmation of any evidence as to the composition of one of these products of the food, namely, the excrements, if we found that the estimates arrived at by the direct analysis of them, were consistent with those of the amounts of the constituents consumed in the food, taken in connection with the quantities devoted to the growth of the body, to the respiration, perspiration, &c. It must be confessed, that there is still much to learn in reference to these points, but, at the same time it must be admitted, that the recorded information which we do possess is not

only considerable, but very much confirmatory of the direct results obtained as to the amount and composition of the excrements, and it is, therefore, worthy of some consideration in a discussion of this question. It is, then, with the mixed purpose of bringing together much useful information as to the statistics of food—a subject of itself of the highest importance—at the same time of affording security to the evidence to be adduced as to the average composition of the excrements of a large population; and, further, of supplying a useful collection of material for the study of the physician and physiologist, that the tables which now follow have been arranged.

In Table II. are given estimates of the amounts of carbon and of nitrogen consumed *per day in the food* of individuals of different classes, ages, and sexes.

In Table III. are registered the amounts of carbon expired daily by the lungs, also by persons of different ages and sexes.

And, in Table IV., in like manner are given the registered daily amounts of solid and liquid excrements voided by different persons, and also, as far as practicable, the amount of the valuable constituents contained in those excrements.

TABLE II.

Ounces of Carbon and Nitrogen consumed in Food in 24 hours. Estimated from Dietsaries, or by direct analysis of food.

MALES.

(CHIEFLY MALES, NOT EXCEEDING 15 YEARS.)

Cases, Ages, &c.	Authority or Locality.	By whom estimated.	Carbon.	Nitrogen.	Nitrogen to 100 Carbon.	Notes.
School	Greenwich Hospital	Lawes and Gilbert	8.22	0.39	4.74	
Public Establishment, 646 Boys ...	Porter	ditto	8.88	0.49	5.52	
„ both Sexes ... }	ditto	ditto	6.48	0.35	5.40	
„ 10 Adults ... }						
„ 106 Children }	ditto	ditto	7.26	0.36	4.96	
Public Establishment, 290 both Sexes ... }						
Public Establishment, 365 Males }	ditto	ditto	7.34	0.39	5.31	
„ 67 Females }						
„ 5 Adults ... }	Playfair	Playfair	6.71	0.39	5.81	
Blue Coat Boys ... }						
Mean of schools, establishments of boys, &c.			7.48	0.39	5.29	
Prisoners, with labour, 1 to 2 months ... }	Swaffham	Lawes and Gilbert	8.37	0.39	4.66	
„ no labour, 1 to 4 months }						
„ with labour, 2 to 4 months }						
„ no labour, 4 and upwards }						
„ labour, exceeding 4 mon. }	ditto	ditto	9.12	0.43	4.71	
Punished for prison offences ... }	ditto	ditto	7.00	0.33	4.71	
Prisoners not exceeding 1 month }	Cork	ditto	6.15	0.30	4.80	
Children with Troops embarked ... }	...	ditto	3.84	0.17	4.37	
Mean of boys in prisons, &c.			7.20	0.34	4.67	
Children in Workhouses, 1 to 3 yrs. ...	St. Alban's	Lawes and Gilbert	3.15	0.16	5.08	
„ 3 to 10 yrs. ...	ditto	ditto	4.90	0.34	6.94	
„ under 7 yrs. ...	Greenwich	ditto	5.85	0.25	4.27	
„ 7 to 12 yrs. ...	ditto	ditto	5.97	0.25	4.19	
„ 12 to 16 yrs. ...	ditto	ditto	7.79	0.34	4.36	
Mean of boys in workhouses			5.53	0.27	4.97	
Boy 6½ years, by direct analysis of food	Barral	Barral	5.45	0.28	5.14	
Mean of males not exceeding 15 years			6.73	0.33	4.98	

TABLE II. (CONTINUED.)—Ounces of Carbon and Nitrogen consumed in Food in 24 hours. Estimated from Dietsaries, or by direct Analysis of Food.

(MALES OVER 16 YEARS—VARIOUS CLASSES.)

Cases, Ages, &c.	Authority or Locality.	By whom estimated.	Carbon.	Nitrogen.	Nitrogen to Carbon as 100.	Notes.
Scheme for victualling Navy ...	...	Lawes and Gilbert	16.54	0.80	4.86	
General Naval Dietary ...	...	ditto	17.88	0.83	4.63	
Sailors, on Troop Transports ...	...	ditto	14.72	0.65	4.41	
Sailors, dragging boats over ice ...	Parry	ditto	14.83	1.08	7.31	
„ ordinary ship duty, Polar regions ...	ditto	ditto	11.13	0.81	7.31	
„ fresh meat diet ...	Playfair	Playfair	10.08	0.79	7.84	
„ salt meat do. ...	ditto	ditto	12.49	0.93	7.41	
Mean of sailors	...	...	13.95	.84	6.25	
Soldiers, English, abroad, peace duty ...	...	Lawes and Gilbert	15.28	0.78	5.10	
„ „ Field operations ...	...	ditto	19.20	0.98	5.10	
„ „ embarked ...	...	ditto	11.83	0.52	4.38	
„ German ...	Liebig	Liebig	13.90	0.65	4.65	
„ English ...	Playfair	Playfair	9.47	0.82	8.65	
„ European in India and Jamaica ...	ditto	ditto	9.47	0.77	8.18	
„ Dutch, in peace ...	ditto	ditto	10.11	0.56	5.50	
„ „ in war... ..	ditto	ditto	10.58	0.80	7.55	
„ and Sailors, mean of ...	ditto	ditto	10.46	0.74	7.04	
Pensioners ...	Greenwich	ditto	10.35	0.55	5.36	
„ „ „ „ „	Chelsea	ditto	11.15	0.68	6.10	
„ full diet ...	Greenwich	Lawes and Gilbert	12.27	0.65	5.26	
„ half diet ...	ditto	ditto	9.43	0.41	4.34	
„ mean of full and half ...	ditto	ditto	10.85	0.53	4.86	
Mean of soldiers and pensioners	...	...	11.74	0.67	5.86	
Prisoners, hard labour, 1 to 2 mon.	Swaffham	Lawes and Gilbert	8.97	0.42	4.68	
„ „ 2 to 4 mon.	ditto	ditto	10.54	0.50	4.75	
„ „ exceeding 4 m.	ditto	ditto	11.37	0.52	4.63	
„ military, full, under 84 days ...	...	ditto	9.02	0.43	4.81	
„ „ over 84 days ...	...	ditto	10.96	0.53	4.82	
„ German, with labour ...	Liebig	ditto	10.50			
Mean of prisoners with labour	..	..	10.23	.48	4.74	
Adult Lunatics ...	Hanwell	Dr. R. A. Smith	..	1.01	...	
M. Barral, age 29 years, summer...	Barral	Barral	9.35	0.75	8.00	
„ „ „ „ winter ...	ditto	ditto	12.93	0.99	7.64	
Man, 59 years, spring ...	ditto	ditto	11.71	0.96	8.23	
Dr. Dalton ...	Dalton	Dalton	11.50	1.5	13.04	
Mean of individual experiments	...	...	11.37	1.05	9.23	
Workhouse, ...	St. Albans	Lawes and Gilbert	7.14	0.51	7.14	
„ „ „ „ „	Bedford	ditto	9.19	0.45	4.92	
„ „ „ „ „	Pembroke	ditto	8.80	0.42	4.82	
„ under 60 years ...	Greenwich	ditto	7.91	0.35	4.42	
„ over 60 years ...	ditto	ditto	8.25	0.55	6.67	
„ „ „ „ „	Poor Law Commission.	ditto	7.86	0.40	5.15	
„ average of ...	Playfair	Playfair	8.34	0.38	4.56	
Mean of adult males in workhouses	..	..	8.21	0.44	5.38	
Union Infirmary ...	St. Albans	Lawes and Gilbert	6.15	0.47	7.64	
Hospital do., low diet ...	Greenwich	ditto	4.94	0.18	3.64	
Mean of adult males in infirmaries	...	...	5.55	0.33	5.64	

TABLE 2.—(CONTINUED).—Ounces of Carbon and Nitrogen consumed in Food in 24 hours. Estimated from Diaries or by direct Analysis of Food. (Males over 16 years—various classes.)

Cases, Ages, &c.	Authority or Locality.	By whom estimated.	Carbon.	Nitrogen.	Nitrogen to Carbon as 100.	Notes.
Prisoners, close confinement ...	Swaffham	Lawes and Gilbert	8.80	0.42	4.77	
„ prison offences, 3 days...	ditto	ditto	6.40	0.30	4.69	
„ not exceeding 1 month	Cork	ditto	7.66	0.36	4.72	
„ military, under 84 days, } reduced diet ...	...	ditto	7.88	0.38	4.82	
„ „ over 84 days, } reduced diet ...	...	ditto	9.02	0.43	4.77	
„ German ...	Liebig	Liebig	8.50	...	...	
Mean of adult male prisoners without labour	...	...	8.04	.38	4.75	
Mean of the cases of adult males ...	...	...	10.51	0.65	5.89	
Mean of the classes of adult males	...	...	9.87	0.59	5.98	

FEMALES.

CHIEFLY FEMALES—NOT EXCEEDING 16 YEARS.						
Asylum, 158 girls, 9 adults ...	Porter	Lawes and Gilbert	6.43	0.32	4.98	
Establishment of both sexes, 106 } children, 10 adults ...	ditto	ditto	6.48	0.35	5.40	
Workhouse, 1 to 3 years ...	St. Albans	ditto	3.15	0.16	5.08	
„ 3 to 10 years ...	ditto	ditto	4.90	0.34	6.94	
„ under 7 years ...	Greenwich	ditto	5.85	0.25	4.27	
„ 7 to 12 years ...	ditto	ditto	5.97	0.25	4.19	
„ 12 to 16 years ...	ditto	ditto	7.79	0.34	4.36	
Children with troops embarked } under 10 years ...	...	ditto	3.84	0.17	4.37	
Mean of Females under 16 years ...	...	...	5.55	0.27	4.95	
ADULT FEMALES.						
Woman 32 years ...	Barral	Barral	10.34	0.79	7.64	
Women with troops embarked ...	...	Lawes and Gilbert	7.69	0.34	4.37	
Workhouse, scheme for ...	Poor Law Commission.	Lawes and Gilbert	6.68	0.32	4.83	
„ „ „ ...	Bedford	ditto	7.87	0.40	5.05	
„ average of ...	Playfair	Playfair	7.73	0.37	4.79	
Mean of Women in workhouses ...	...	...	7.43	.36	4.89	
Prisoners, hard labour, 1 to 2 mon. }	Swaffham	Lawes and Gilbert	8.37	0.39	4.66	
„ no labour, 1 to 4 months }	...	...	...	...	...	
„ hard labour, 2 to 4 mon. }	ditto	ditto	8.74	0.42	4.80	
„ no labour, 4 months and upwards ...	...	...	...	...	...	
„ hard labour, over 4 mon. }	ditto	ditto	9.12	0.43	4.71	
„ close confinement for }	ditto	ditto	7.00	0.33	4.71	
prison offences ...	ditto	ditto	7.00	0.33	4.71	
„ not exceeding 1 month	Cork	ditto	6.58	0.31	4.73	
Mean of Women in prisons ...	...	...	7.96	0.38	4.72	
FAMILIES, &c.—MIXED AGES AND SEXES.						
Fashionable Family in Town, 6 } male adults, 6 female adults, and } 6 children ...	Porter	Lawes and Gilbert	9.86	0.53	5.37	
Fashionable Family in Town, 5 } male adults, 6 female adults, 6 } children ...	ditto	ditto	8.73	0.47	5.38	
Trading Establishment in the City, } male and female adults, 114 ... }	ditto	ditto	8.69	0.49	5.64	
Family at Giessen, 5 adults, 4 } children ...	Liebig	ditto	9.50	...	...	
Mean of Families, &c.—Mixed ages and sexes	...	...	9.19	0.50	5.46	
Mean of Females under 16 years	...	...	5.55	0.27	4.95	
Mean of Adult Females	...	...	8.01	0.41	5.03	

The difference between the amounts of certain constituents consumed in the food, and the sum of those of them given off by the respiration and in the solid and liquid excrements, should, of course, represent that which goes to the increase of the body, and to the indeterminate exhalations.

It might have been well, in a more extended treatment of the subject, to have traced other constituents of the food than merely the carbon or the nitrogen. But the reason that these two are selected as of the most importance is, that the former, namely, carbon, is one of the most characteristic and most easily traced of the constituents, both of the food and of the products of respiration, and thus the facts relating to it in these, afford the best check upon the amount determined in the excrements. The nitrogen, on the other hand, is undoubtedly the most important *memorial* constituent in the excrements, and it is certainly the one which will measure—though not to the exclusion of other matters—their economical value. Our recorded results respecting the probable amounts of the latter which are exhaled by the respiration and perspiration, and therefore lost to the manure, are by no means so satisfactory as could be wished; but such is the importance of this question—one which most intimately affects the economy of the feeding of stock—that it is, perhaps the more desirable to sift such evidence as we do possess respecting it, and thereby, at any rate, indicate a useful path for future inquiry. This subject, so far as the animals of the farm are concerned, has been more laboriously investigated at Rothamsted, than perhaps any other, though, owing to the practical difficulties involved in it, without that success which had been hoped for.

But to return to the question of what is our evidence respecting the consumption, and the appropriation, of the constituents of the food of a human population of mixed sexes and ages—and what is the probable proportion of the nitrogen of the food which finds its way into the sewers?

In Table II., as has been stated, are given the estimates of the amounts of carbon and of nitrogen consumed in food in 24 hours, in 86 different cases, which are again arranged in 15 classes, according to sex, age, activity of mode of life, and other circumstances. Most of these estimates have been made by calculating the known average amounts of carbon and nitrogen in the articles composing the dietary in each particular case; the particulars of the dietaries themselves having been obtained some years ago with a special view to this question of sewage. Some of the estimates in the table have, however, been kindly provided by Dr. Lyon Playfair; whilst a few of them, as will be seen by reference to the columns of "authority," have been made by other individuals; and generally in these latter cases, the food actually consumed within a given time, has being weighed, and its constituents determined in some instances by estimation, and in others by direct analysis.

It cannot of course be pretended, that the classes of individuals whose dietaries constitute the main bulk of those in the table, represent, so far as exact form of food or cookery is concerned, all the various grades of society in the metropolis. But it may safely be assumed that, provided the sex, age, constitution, and habits of life as to air and exercise are the same, the amounts of the important *ultimate constituents* of food will not materially differ. It would seem, that the main difference in this particular respect, will be, that the more luxurious the quality of the food, the more concentrated will be the supply of carbon and of nitrogen in a given weight of the dry substance of the food, and the larger will be the proportion of hydrogen and the less of oxygen in that dry substance.

With regard to the numerical indications of this table of dietaries, independently of their connection with those on respiration and of excrements, it may be noticed that the average relation of the nitrogen to the carbon of the food, is $5\frac{1}{2}$ of the former to 100 of the latter.

In applying the results of this table to elucidate our main question, namely, the composition of the excrements of the population of London—the latter is taken at 2½ millions; and this number is supposed to comprise males and females of various ages in the proportions given in the last census. It has next been assumed, that all males under 15 years consume the amounts of carbon and nitrogen given in the dietary table for males under that age, in schools, in public establishments of boys, in prisons, in workhouses, &c., and in any cases of individual experiment. The various classes of males over 15 in the metropolis are supposed to be represented, so far as the carbon and nitrogen they consumed is concerned, by the average of sailors, of soldiers, and pensioners, of prisoners with labour, of prisoners without labour, of men in workhouses, in infirmaries, as well as of certain individual cases of direct experiment. And again, the average given in the table of children in workhouses under 16 years, and of girls in various asylums and public establishments, &c., is applied to the female inhabitants under 15 years. That, on the other hand, given of women in workhouses, in prisons with and without labour, with soldiers embarked, and of a case of individual experiment, is supposed to apply to the adult female population. There are also given, the calculated dietaries of several families and other establishments, of mixed ages and sexes, of different grades of society, the results of which fully confirm the indications of those of the other classes, and at the same time justify the appropriation, for our present purpose, of the figures given for the various classes in the manner above-mentioned. The *average*, thus taken of the amounts of carbon and nitrogen consumed per head per day for each of the divisions as to sex and age, is multiplied by the number of individuals of each such division, and the figures thus obtained for the several division being added together, we obtain, of course, the amounts of carbon and of nitrogen consumed by the total population in one day; and from this is easily ascertained the annual consumption.

Before leaving the question of the amount of the constituents consumed in food, it may be well to notice a point of some national interest and importance, which the calculation of the various dietaries may help to elucidate, namely, the probable average consumption of wheat by each individual of the population. This has been variously estimated at from six to eight bushels per head per annum. The amounts of bread, flour, &c., registered in the dietaries, which have been calculated, lead to the conclusion that $6\frac{1}{2}$ to $6\frac{3}{4}$ bushels is about the average amount so consumed. Another point illustrated by the calculations is, that the average quantity of the *dry substance of food*—that is, excluding the water it naturally contained—is, within a very small fraction, one pound per head per day, including both sexes and all ages.

We now come to the second main element in our calculation, namely, to a consideration of what amount of the carbon of the food escapes by the lungs. And when it is borne in mind that this expiration by the lungs in the form of carbonic acid, is the chief destination of that constituent in the food, and, therefore, that the amount thus traced, together with that found in the excrements, should very nearly make up the quantity taken in the food, the important bearing of results of this kind will at once be obvious. On this point, then, we have, in Table III., the amounts of the carbon of the food expired in a given time by persons of different sexes and ages, according to the results of direct experiments on respiration made by various chemists and physiologists. The chief labourers in this field of inquiry have been Messrs. Allen and Pepys, Dr. Dalton, MM. Dumas, Dulong, and Despretz, Mr. Coathupe, M. Scharling, and MM. Andral and Gavarret. To the latter gentlemen—namely, MM. Andral and Gavarret—we are indebted for a very extensive series of determinations of the amount of carbon expired by the lungs in a given time by persons of both sexes and at different ages. These experiments were made

TABLE III.

Ounces of Carbon expired in 24 hours. Estimated by direct experiment on Human Respiration.

Ages, Cases, &c.		By whom estimated.	Males.	Females.
Not over 15 years.	8 years	Andral and Gavarret	4.24	
	10 do.	do.	5.76	5.08
	11 do.	do.	4.44	5.35
	12 do.	do.	5.27	
	12 do.	do.	7.03	
	13 do.	do.		5.34
	14 do.	do.	6.95	
	15 do.	do.	7.37	
	15 do.	do.		6.01
	15 do.	Scharling.	4.70	
	10 do.	do.		4.43
Average under 16 years			6.09	5.24
15 to 20 years.	16 years	Scharling.	7.92	
	19 do.	do.		5.84
	15½ do.	Andral and Gavarret		5.34
	16½ do.	do.	8.64	
	17 do.	do.	8.64	
	18 do.	do.	9.40	
	19 do.	do.	9.49	5.93
	20 do.	do.	9.49	
Average from 15 to 20 years			8.93	5.71
20 to 30 years.	22 years	Andral and Gavarret.		5.68
	24 do.	do.	9.40	
	25 do.	do.	9.83	
	26 do.	do.	11.95	5.08
	26 do.	do.	9.32	5.34
	27 do.	do.	10.00	
	28 do.	do.	10.50	
	Dr. Dalton	Dalton.	10.25	
	M. Dumas, 20 years	Dumas.	5.88	
	A Soldier, 28 years	Scharling.	8.46	
Average from 20 to 30 years			9.51	5.37
30 to 40 years.	31 year	Andral and Gavarret.	9.49	
	32 do.	do.	9.74	5.25
	33 do.	do.	9.06	
	37 do.	do.	9.06	
	38 do.	do.		6.61
	40 do.	do.	10.25	
	38 do.	Allen and Pepys.	11.00	
	38 do.	Coathupe.	5.45	
	35 do.	Scharling.	7.75	
Average from 30 to 40 years			8.97	5.93
40 to 50 years.	41 years.	Andral and Gavarret.	8.81	
	42 do.	do.		7.03
	43 do.	do.		7.29
	44 do.	do.		8.39
	45 do.	do.	7.33	5.25
	48 do.	do.	8.90	
	49 do.	do.		6.27
	50 do.	do.	9.06	
Average from 40 to 50 years			8.52	6.85
50 to 60 years.	51 years	Andral and Gavarret.	8.56	
	52 do.	do.		6.35
	54 do.	do.	8.98	
	56 do.	do.		6.01
	59 do.	do.	8.47	
Average from 50 to 60 years			8.67	6.18
60 to 70 years.	64 years.	Andral and Gavarret.	7.37	5.85
	66 do.	do.		5.76
	68 do.	do.	8.13	
Average from 60 to 70 years			7.72	5.80
70 upwards.	76 years.	Andral and Gavarret.	5.08	5.59
	82 do.	do.		5.08
	92 do.	do.	7.45	
	102 do.	do.	5.00	
Average from 70 upwards			5.84	5.33
Average from 15 to 40 years			9.17	5.63
Average from 40 upwards			7.76	6.26
Average from 15 to 50 years			9.07	6.10
Average from 50 upwards			7.38	5.77

upon more than seventy individuals, half of them of the male, and half of the female sex. It would be out of place here to dwell on certain most important physiological bearings of these experiments; but it may be submitted, in passing, that a careful study of them would well repay the intelligent physician, and especially those who devote themselves more exclusively to diseases of the respiratory organs. Such a study might, at least give a very useful turn to future observation and inquiry; if not, indeed, at once suggest valuable practical conclusions.

With regard to the applicability of experiments of this kind to a practical discussion as to the average amount of carbon expired by a mixed population within a given time, such, for instance, as the entire period of twenty-four hours, or of a whole year, it may be said, that, as such experiments are made only during a state of wakefulness, their indications must be too high for the period of the night. On the other hand, since they are, also, only made whilst the individual is at rest, their results would be too low for the periods of exposure and exercise. These two sources of error tend to balance each other therefore, and in point of fact, the very obvious and uniform relation of the amounts of carbon shown to be expired to those consumed in the food, would indicate that the resultant error cannot be very great. And if any judgment were to be formed of the *direction* of the discrepancy from the comparison with the amounts consumed, and a consideration of the amounts appropriated by the other requirements of the body, it would be concluded that, upon the whole, the figures indicating the quantity expired by the lungs are, perhaps, somewhat too low.

An inspection of Table III. shows that, up to the age of about 15 or 16 years there is a gradual increase in the amount of carbon consumed by both sexes, the actual quantity being always rather higher for the male. From this period the quantity still increases in the case of the male until past middle, or to comparative old age, when it begins gradually to diminish. With the female, on the other hand, this consumption by the lungs remains stationary in amount from the age of 15 or 16 years to about 40. It then for a time somewhat increases; and finally, as in man decreases with old age—the female, however, always keeping an average somewhat below that of the male.

A comparison of the amounts of carbon consumed in food in 24 hours with those of it expired by the lungs during the same period, shows a general average of from one to one and half ounces more in the food than is expired. It will presently be seen that a large portion of this difference is accounted for by the carbon contained in the excrements, leaving an average of something less than three-fourths of an ounce for the daily growth of the body, for nasal and other incidental excretions, and for the perspiration. The consistency of the indications in experiments of so opposite a kind, and made with such opposite views, is at any rate surprising, and such as to leave no doubt of the general practical utility of the evidence on the several points. This brings us to the third element in the calculation, namely, a consideration of the recorded amounts of the liquid and solid excrements voided by persons of different sex and ages within a given period, and of the amounts of some of the constituents of those excrements.

In Table IV are arranged the amounts of fresh excrements, or of certain of their constituents, voided in 24 hours by persons of different sex and ages, as recorded by various experimenters. The columns in the Table are headed respectively—"Fresh Excrements," "Dry Substance," "Mineral Matter," "Carbon," "Nitrogen," and "Phosphates," and the quantities given by the various experimenters of any or of all these substances, as the case may be, are entered in these columns. In all cases, however, in whatever weights or measures the experiments are originally stated, they have been reduced to the uniform denomination of ounces (tenths, &c.) in our Table. In many cases, too, the amount of certain compounds only of nitrogen which the excrements con-

TABLE IV.
OUNCES OF HUMAN EXCREMENTS, AND THEIR CONSTITUENTS, IN 24 HOURS. QUOTED OR CALCULATED FROM VARIOUS EXPERIMENTERS.

Cases, Ages, &c.	Duration of Experiment.	Authority.	Fresh Excrements.			Dry Substance.			Mineral Matter.			Carbon.			Nitrogen.			Phosphates.		
			Feces.	Urine.	Total.	Feces.	Urine.	Total.	Feces.	Urine.	Total.	Feces.	Urine.	Total.	Feces.	Urine.	Total.	Feces.	Urine.	Total.
MALES UNDER 15 YEARS.																				
Boy, 6½ years	5 days	Barral	2.96	18.36	21.32	0.760	0.560	1.320	0.101	0.181	0.282	0.343	0.155	0.498	0.064	0.110	0.174	...	...	...
Child, 3 years	3 "	Lecanu	...	13.71*	...	...	...	...	...	...	...	...	...	...	...	0.109*	...	...	...	...
Child, 4 years	1 "	"	...	14.65*	...	...	...	...	...	...	...	...	...	...	...	0.138*	...	...	...	...
Boy, 8 years	4 "	"	...	28.44	...	...	...	...	...	0.355	...	...	...	...	...	0.237	...	...	...	...
do. do.	4 "	"	...	22.51	...	...	...	...	...	0.355	...	...	...	...	...	0.235	...	...	...	...
Mean of Males under 15 years																				
...	...	...	2.96	19.63	22.49	0.760	0.560	1.320	0.101	0.207	0.398	0.343	0.155	0.498	0.064	0.106	0.230	...	...	...
MALES FROM 15 TO 50 YEARS.																				
Dr. J. Lining.	Entire year	Lining	3.97	59.10	63.07	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Man, 29 years,	5 days	Barral	4.99	39.62	44.61	1.240	1.830	3.060	0.200	0.513	0.713	0.540	0.537	1.077	0.099	0.380	0.479	...	...	...
do. do.	5 "	"	2.66	36.12	38.78	0.730	1.620	2.350	0.180	0.438	0.568	0.314	0.484	0.798	0.046	0.330	0.396	...	...	...
do. 20 do.	12 "	Lecanu	...	35.19	...	...	...	...	...	0.396	...	...	...	...	...	0.471	...	...	...	...
do. 22 do.	12 "	"	...	34.02	...	...	...	...	...	0.396	...	...	...	...	...	0.472	...	...	...	...
do. 35 do.	6 "	"	...	61.18	...	...	...	...	...	...	...	...	...	...	...	0.503	...	...	...	...
do. 38 do.	12 "	"	...	33.61	...	...	...	...	...	0.396	...	...	...	...	...	0.444	...	...	...	...
do. 38 do.	10 "	"	...	70.60	...	...	...	...	...	...	...	...	...	...	...	0.359	...	...	...	...
do. 43 do.	12 "	"	...	37.34	...	...	...	...	...	0.396	...	...	...	...	...	0.500	...	...	...	...
Young Man on Mixed diet	13 "	Lehmann	...	40.21	...	...	2.390	...	...	0.338	...	...	...	...	...	0.550	...	...	0.184	...
do. Purely Animal diet	12 "	"	...	31.99	...	...	3.016	...	...	...	...	...	...	...	...	0.895	...	...	0.321	...
do. Purely Vegetable diet	12 "	"	...	31.99	...	...	2.096	...	...	...	...	...	...	...	...	0.581	...	...	0.133	...
do. Non-Nitrogenous diet	2 "	"	...	36.89	...	...	1.470	...	...	...	...	...	...	...	...	0.260	...	...	0.136	...
do. Daily severe exercise	...	"	...	34.69	...	...	2.920	...	...	...	...	...	...	...	...	0.745	...	...	0.201	...
...	...	"	4.24	...	...	1.06	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	"	6.35	...	...	1.59	...	...	...	0.524	...	...	...	...	...	...	...	...	...	...
24 men—20 to 25 years	Several days	Chambert	...	40.15	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Healthy middle aged man	...	Thomson	...	53.30	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Normal adult	...	Rayer	...	44.34	...	...	...	...	...	...	...	...	...	...	...	...	0.592	...	...	0.143
do. do.	...	Haller	...	53.31	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
do. do.	...	Bostock	...	45.15	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
do. do.	...	Prout	...	56.80	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
German soldier	...	Playfair	5.50	...	...	1.375	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Man, 28 years	7 days	Wray	3.23	...	...	0.831	...	...	...	0.095	...	...	...	...	...	0.046	...	...	0.077	...
do. 19 do.	2 "	"	3.07	...	...	0.821	...	...	...	0.094	...	...	...	...	...	0.035	...	...	0.076	...
do. 17 do.	2 "	"	...	...	...	0.557	...	...	...	0.064	...	...	...	...	...	0.039	...	...	0.052	...
Dr. Dalton	14 "	Dalton	2.73	48.50	51.23	3.250	1.210	4.460	...	...	...	0.485	0.610	1.095	...	...	...	...	...	...
do. do.	7 "	"	4.83	42.00	46.83	1.080	2.810	3.890	...	...	...	0.433	0.525	0.958	...	...	...	...	...	...
Mean of 4 men	...	Bequerel	...	44.73	...	1.296	...	...	...	0.350	...	...	...	...	...	0.294	...	...	...	...
Person No. 1	...	Chossat	...	...	...	0.700	...	...	...	...	...	...	...	...	...	...	...	...	...	...
do. No. 2	...	"	...	...	...	0.890	...	...	...	...	...	...	...	...	...	...	...	...	...	...
do. No. 3	...	"	...	...	...	0.896	...	...	...	...	...	...	...	...	...	...	...	...	...	...
do. No. 4	...	"	...	...	...	1.140	...	...	...	...	...	...	...	...	...	...	...	...	...	...
do. No. 5	...	"	...	...	...	1.176	...	...	...	...	...	...	...	...	...	...	...	...	...	...
do. No. 6	...	"	...	...	...	1.220	...	...	...	...	...	...	...	...	...	...	...	...	...	...
do. No. 7	...	"	...	...	...	1.170	...	...	...	...	...	...	...	...	...	...	...	...	...	...
do. No. 8	...	"	...	...	...	1.299	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mean of Males from 15 to 50 years																				
...	...	...	4.17	46.01	50.18	1.041	1.735	2.776	0.116	0.327	0.643	0.443	0.599	0.982	0.053	0.478	0.531	0.068	0.189	0.257

* These quantities are one-half more than given by M. Lecanu, as he states that that portion or more was lost

TABLE 4.—(CONTINUED).—*Ounces of Human Excrement, and their Constituents, in 24 Hours. Quoted, or Calculated, from Various Experimenters.*

Cases, Ages, &c.	Duration of Experiments.	Authority.	Fresh Excrements.		Dry Substance.		Mineral Matter.		Carbon.		Nitrogen.		Phosphates.	
			Fæces.	Urine.	Fæces.	Urine.	Fæces.	Urine.	Fæces.	Urine.	Fæces.	Urine.	Fæces.	Urine.
MALES FROM 50 YEARS UPWARDS.														
Healthy person, 50 to 60 years	10 days	Thomson	...	...	...	...	...	...	...	...	...	...	...	...
Man, 53 years	12 "	Lecanu	...	...	...	...	0.248	...	...	...	...	0.587	...	0.142
Do. 85 years	4 "	"	...	...	...	...	...	...	...	...	...	0.500	...	...
Do. 86 years	6 "	"	...	...	...	...	...	...	...	...	...	0.194	...	...
Do. 59 years, Spring	5 "	Barral	6.20	63.06	69.26	1.160	2.260	3.420	0.228	0.432	0.660	0.480	0.748	1.228
Mean of males from 50 years upwards			6.20	42.05	48.25	1.160	2.260	3.420	0.228	0.340	0.568	0.480	0.748	1.228
FEMALES NOT OVER 16 YEARS.														
Child, 3 years	3 days	Lecanu	...	...	...	...	...	...	...	...	...	...	...	...
Child, 4 years	1 "	"	...	...	...	...	...	...	...	...	...	...	...	...
Girl, 16 years	8 "	"	...	...	...	...	...	...	...	...	...	...	...	...
Mean of females not over 16 years			...	...	...	...	...	...	...	...	...	...	...	...
ADULT FEMALES.														
Woman, 19 years	4 days	Lecanu	...	...	...	...	...	...	...	...	...	...	...	...
Do. 19 years	4 "	"	...	...	...	...	...	...	...	...	...	...	...	...
Do. 28 years	8 "	"	...	...	...	...	...	...	...	...	...	...	...	...
Do. 43 years	3 "	"	...	...	...	...	...	...	...	...	...	...	...	...
Do. 32 years	5 "	Barral	1.24	40.85	42.09	0.330	1.550	1.880	0.044	0.350	0.394	0.148	0.495	0.643
Mean of 4 women		Bequerel	...	...	...	...	...	...	...	...	...	...	...	...
Mean of adult females			1.24	36.66	37.90	0.330	1.380	1.710	0.044	0.323	0.367	0.148	0.495	0.643
SUMMARY.														
Mean of males under 16 years			2.96	19.53	22.49	0.760	0.560	1.320	0.101	0.297	0.398	0.343	0.155	0.498
Do. from 16 to 50 years			4.17	46.01	50.18	1.041	1.735	2.776	0.116	0.527	0.643	0.443	0.539	0.982
Do. from 50 years upwards			6.20	42.05	48.25	1.160	2.260	3.420	0.228	0.340	0.568	0.480	0.748	1.228
Do. all ages			4.24	41.38	48.10	1.034	1.703	3.083	0.130	0.451	0.556	0.432	0.510	0.942
Mean of females not over 16 years			...	...	...	...	...	...	...	...	...	...	...	...
Mean of adult females			1.24	36.66	37.90	0.330	1.380	1.710	0.044	0.323	0.367	0.148	0.495	0.643
Mean of females of all ages			1.24	31.04	32.28	0.330	1.380	1.710	0.044	0.322	0.367	0.148	0.495	0.643
Calculated average per head of total population of London														
DIRECT EXPERIMENTS AT ROTTERDAM.														
Man, 46 years	8 days	Lawes and Gilbert	...	...	...	...	...	...	...	...	...	...	...	...
Do. 50 years	8 "	"	6.700	54.600	61.300	1.469	1.517	2.986	0.180	0.678	0.858	...	...	...
Mean of 8 boys—6, 10, & 12 years	4 "	"	4.815	22.952	27.767	0.920	0.904	1.824	0.090	0.352	0.472	...	...	...

* These quantities are one-half more than given by M. Lecanu, as he states that that proportion or more was lost.

tained, have been given, such as urea and uric acid, and in these instances the amounts of nitrogen as entered in the Table, have been calculated according to the known composition of those two substances. In the event, therefore, of the urine containing any small amount of other compounds of nitrogen, the quantities thus arrived at will be rather too low, though any error arising from this source can be but comparatively insignificant. The figures indicating the amount of phosphates, again, is in many cases only deduced from that of phosphoric acid or various compounds of it, originally recorded. In these cases the amount is represented as the earthy phosphate of lime. Such, then, are the best data respecting the amount and composition of human excrements at our command. It is seen that there are many more determinations of the amount and of the constituents of urine than of feces; and since the urine not only contains by far the larger part of the nitrogen of the excrements—indeed, seven or eight times as much as the feces, but it is also more liable to variation according to sex, age, diet, exercise, and other causes—this is so much the better for the purposes of obtaining a general average. There are very few experiments at all referring either to boys or girls not exceeding 15 or 16 years; and there are much fewer for adult women than for men. The number of experiments on adult males is, however, sufficient both as to urine and feces. On adult females they are so, perhaps, so far as urine is concerned, but we have only one recorded experiment of the amount of feces voided by woman in a state of health, though there are some under disease, and the one in question is obviously very low, judging by the relative amounts of food consumed by the two sexes. It is possibly owing to the comparatively limited number of the experiments on the excrements of women, that we find a somewhat larger average proportion of loss of nitrogen indicated for the female, than for the male part of the population. When, however, we consider that the nitrogenous contents of the urine depend much upon the activity of the person, we might expect, on this ground, to find a larger proportion so voided by men than by women. On the other hand, it must be admitted, that we have no sufficient means of deciding in what manner the exhalation in the gaseous form of nitrogen, derived from the food—and, therefore, lost to the excrements—is affected by the degree of rest or activity of the body.

Whilst referring to the question of the proportion of nitrogen lost to the excrements beyond the amount which is devoted to the increase of the body, we may briefly notice the state of our knowledge on the subject of the exhalation of nitrogen derived from the food by the lungs and skin.

Many experiments have from time to time been made, to determine whether or not part of the nitrogen of the food is exhaled by the lungs. Some of the results on this head appear to carry with them their own refutation. Thus, for instance, the amounts estimated to be exhaled by MM. Dulong and Despretz, in some instances would far exceed the total average proportion of nitrogen to carbon in the food consumed by the animal. Some of the results of M. Edwards exhibit a similar anomaly. It should be stated, that the amount of nitrogen evolved by an animal under experiment is, according to the method of the experimenter, represented either in relation to the total oxygen consumed by the respiration in the same period of time—to the amount of oxygen given off in combination with carbon as carbonic acid—or to the amount of carbonic acid itself evolved. It will be more convenient, however, for our purpose, to speak of this evolution in relation to the amount of carbon expired, or contained in the food, or to the total amount of nitrogen itself consumed in the food. Reduced to the above standards of comparison, the amounts of nitrogen which Marchand found evolved by the respiration of small herbivorous animals, were about 2 to every 100 of carbon expired. According to the results of MM. Regnault and Reiset, which

are perhaps the best series on this subject, they consider that there are seldom 3 parts of nitrogen evolved to 100 of carbon—and never double that amount. They estimate that less is evolved on an animal than a vegetable diet. This latter point accords in the main with the direction of the results of MM. Dulong, Despretz, and Edwards, and also with conclusions arrived at by Bischoff, derived from a totally different class of experiments, namely, those on the circumstances affecting the amounts of nitrogen voided in the urine. Magnus also considers that nitrogen is evolved. Pfaff and others, however, confute this opinion.

Upon the whole, it must be admitted, that the bulk of our testimony goes to establish that there is frequently, at least, a loss of some part of the nitrogen of the food in the gaseous form; yet, that as to the amount of this loss under any given circumstances, or its variation, according to diet, class of the animal, age, sex, &c., we have still much to learn.

Experiments of another kind, however, have been made to determine the question indirectly. Thus—M. Boussingault fed a cow and a horse for a certain length of time on food just sufficient to keep their weights constant, and weighed and analysed both their food and their solid and liquid excrements. By this method he found the proportion of the nitrogen of the food which was lost by exhalation, to amount to—

For the Cow . . .	13·37 per cent.
For the Horse . . .	16·55 do.

As before stated, very many experiments of this kind have been made at Rothamsted, the results of which, however, do not justify us in pronouncing an opinion upon what is the range of this gaseous exhalation of nitrogen, or what are the circumstances which increase or diminish it.

So much, then, for the results of direct experiments on respiration made upon small animals, and for those on the food and excrements of the animals of the farm, to determine the gaseous exhalation of nitrogen by the vital processes.

The only experiments of this kind pretending to any detail or accuracy, which have been made upon the human subject, are those by M. Barral, of Paris. M. Barral analyzed the food and the excrements of himself during two periods of five days each, as well as of an elderly man, a woman of 32 years of age, and a boy of 6½ years, each for a like period of time. These experiments were, however, not conducted so much in special reference to nitrogen as to certain other constituents; and there are, moreover, some points in M. Barral's method of treating the excrements which open reasonable doubt whether a portion of their nitrogen was not lost in the process of analysis. The proportions of the nitrogen consumed in the food, which in these experiments were not recovered in the excrements, and which consequently are supposed to be exhaled, were as follows:—

Man, 29 years, in Winter . .	51·01 per cent.
Ditto ditto, in Summer . .	47·59 ditto.
Boy, 6½ years, in February . .	37·97 ditto.
Man, 59 years, in March . .	25·17 ditto.
Woman, 32 years, in May . .	51·83 ditto.

Mean of 5 experiments . . 44·72 per cent.

The results, then, of these direct experiments on the human subject show an apparent exhalation, and therefore loss of nitrogen to the excrements, amounting to nearly 45 per cent. of the nitrogen consumed in the food. It will presently be seen, that this proportion of loss is about twice as great as that arrived at by our method of computing the amounts of nitrogen contained in the food, and in the excrements respectively, of the population of London.

In Table V., the average amounts of carbon expired by the respective sexes at different ages, as given in Table III., are calculated for the number of each of these classes constituting the population of London. We have

TABLE V.
CONSUMPTION OF CARBON AND NITROGEN BY THE TOTAL POPULATION OF LONDON (2½ MILLIONS). POUNDS PER ANNUM, &c.

Ages.	Carbon Expired Estimated by Direct Experiments on Respiration.				Carbon Consumed in Food. Estimated from Diets.				Nitrogen Consumed in Food. Estimated from Diets.			
	Population of London.		Ounces (tenths, &c.) per head in 24 hours.		Total in lbs. per annum.		Ounces (tenths, &c.) per head in 24 hours.		Total in lbs. per annum.		Ounces (tenths, &c.) per head in 24 hours.	
	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.
Under 15 years.....	396,799	400,727	6.09	5.24	55,120,500	47,896,655	6.73	5.55	60,913,131	50,730,234	.33	.27
15 to 20	104,865	121,299	8.93	5.71	21,360,298	15,798,601						
20 to 30	222,223	273,116	9.51	5.37	48,205,302	33,453,899						
30 to 40	180,268	207,168	8.97	5.93	36,883,861	28,022,222						
40 to 50	125,997	143,647	8.52	6.85	24,486,407	22,444,629						
50 to 60	77,369	93,915	8.67	6.18	15,300,697	13,238,810						
60 to 70	43,580	57,468	7.75	5.80	7,703,963	7,602,901						
70 upwards	20,007	31,582	5.84	5.33	2,665,143	3,839,655						
Total—all ages	1,171,108	1,328,922			211,726,171	172,297,372			247,423,727	220,318,980		
SUMMARY.												
Average lbs. per head per annum					180½ lbs.	129½ lbs.			211½ lbs.	165½ lbs.		
Average ozs. per head per day					7.92 ozs.	5.63 ozs.			9.26 ozs.	7.27 ozs.		
Total—both sexes, and all ages—lbs.					384,023,543 lbs.				467,742,707 lbs.			
Average lbs. per annum—both sexes, and all ages					153½ lbs.				187 lbs.			
Average ozs. per day—both sexes, and all ages					6.73 ozs.				8.20 ozs.			

TABLE VI.
ESTIMATED CONSTITUENTS IN THE EXCREMENTS OF THE TOTAL POPULATION OF LONDON (2½ MILLIONS). POUNDS PER ANNUM, &c.

Ages, &c.	Total Population of London. (Taken at 2½ millions.)				Dry Substance.				Mineral Matter.				Carbon.				Nitrogen.				Phosphates.			
	Males.		Females.		Males.		Females.		Males.		Females.		Males.		Females.		Males.		Females.		Males.		Females.	
	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.		
0 to 16 years	396,799	400,727	11,947,300	.....	3,602,292	.....	4,507,390	.....	2,084,727	.....	.....	.....	.....	.....	2,084,727	.....	.....	.....	.....	.....	.....	.....	No estimates given, assumed to be amount of males.	
16 to 50 years	632,353	928,195	40,104,287	.....	9,289,281	.....	14,186,740	.....	7,671,241	.....	.....	.....	.....	.....	7,671,241	.....	.....	.....	.....	.....	.....	.....	3,712,823	
50 upwards	140,956	.....	10,996,006	.....	1,826,237	.....	3,948,273	.....	1,514,362	.....	.....	.....	.....	.....	1,514,362	.....	.....	.....	.....	.....	.....	.....	.....	
Total all ages ...	1,171,108	1,328,922	63,047,573	.....	14,717,810	.....	22,642,403	.....	11,261,330	.....	19,491,073	.....	.....	.....	11,261,330	.....	8,578,497	.....	.....	.....	.....	.....	6,856,233	
SUMMARY.																								
Average per head per annum .....	.....	.....	53.84 lbs.	39.0 lbs.	12.57 lbs.	8.37 lbs.	19.33 lbs.	14.67 lbs.	9.62 lbs.	6.45 lbs.	5.86 lbs.	3.44 lbs.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Average per head per day .....	.....	.....	2.36 ozs.	1.71 ozs.	0.55 ozs.	0.367 ozs.	0.847 ozs.	0.643 ozs.	0.422 ozs.	0.283 ozs.	0.257 ozs.	0.151 ozs.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Total, both sexes and all ages .....	.....	.....	114,882,308	.....	25,842,575	.....	42,133,476	.....	19,845,827	.....	11,442,055	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Average per head per annum, both sexes and all ages .....	.....	.....	45.95 lbs.	.....	10.34 lbs.	.....	16.85 lbs.	.....	7.94 lbs.	.....	4.58 lbs.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Average per head per day, both sexes and all ages .....	.....	.....	2.01 ozs.	.....	0.453 ozs.	.....	0.739 ozs.	.....	0.348 ozs.	.....	0.201 ozs.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Total per annum, both sexes and all ages .....	.....	.....	51,266½ tons	.....	11,536½ tons	.....	18,509½ tons	.....	8,859½ tons*	.....	5,108 tons	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Per cent. in dry substance of mixed excrements, both sexes and all ages .....	.....	.....	.....	.....	22.495	.....	38.675	.....	17.274	.....	9.956	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Per cent. if with 50 per cent. water and impurity .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Per cent. in Mr. Herapath's sewage manure .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Per cent. in sewage manures (with lime), analysed by Professor Way—mean of 3 .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

* Equal 10,755½ tons ammonia.

thus, in the upper portion of this Table V., the amounts of carbon expired per annum, by the number of individuals included in each division according to age and sex. In the other two main divisions of the Table, the average amounts of carbon and nitrogen consumed in food, as deduced from Table II., are as far as practicable, in like manner, applied to the different ages and sexes of the population. And, in the same way in Table VI., the amounts and constituents of the excrements voided in 24 hours, as given in Table IV., are also calculated to their respective divisions of the population. In the lower portions of each of these Tables (V. and VI.), a summary is given, showing the average amounts of the respective constituents consumed, expired, or voided, as the case may be, in 24 hours, and per annum—for each individual of each of the separate sexes—for each individual of the mixed population—and also the total amounts for the total population of the metropolis.

Before entering upon a discussion of the information afforded in Table VI., as to the amounts of the various manurial constituents contained in the excrements of the population of London, it may be well to call attention to a comparative view of the average amounts of carbon and nitrogen consumed in food, exhaled, or voided in excrements, in 24 hours, as indicated by the results arrived at in these Tables (V. and VI.). This comparison is afforded in the following Summary Table:—

TABLE VII.

Ounces (tenths, &c.) of Carbon and Nitrogen per head per day—Consumed in Food—Expired by the Lungs—Voided in Excrements—in Growth, Perspiration, Loss, &c. Average for all Ages of each Sex separately, and for both Sexes collectively.

Sexes, Ages, &c.	CARBON.				NITROGEN.			
	In Food.	Expired by Lungs.	In Excrements.	In Growth, Perspiration, &c.	In Food.	In Excrements.	In Growth, Exhaled, &c.	Per Cent. in Growth and Loss.
Average of Males of all ages	9·26	7·92	0·847	0·493	0·528	0·422	0·106	20·07
Average of Females of all ages	7·27	5·68	0·643	0·947	0·367	0·283	0·084	22·86
Average of both sexes and all ages	8·20	6·73	0·739	0·731	0·440	0·348	0·092	20·91
Average of Families, &c.	9·19	—	—	—	0·500	—	—	—

It is seen, that the sum of the carbon expired and in the excrements, deducted from that in the food, leaves for the growth of the body, for the perspiration, and other minor outlets, an average of about three-quarters of an ounce of carbon per day for each individual of the population. On this point it need only be further stated, that, having taken the weights of several hundred individuals of both sexes and all ages, with a view to calculating the average annual growth of the body, it can safely be affirmed that this amount of carbon is more than sufficient to supply this growth, and that it leaves a considerable margin for the perspiration, and the other demands upon it, which have been referred to; and even after this, a further allowance supposing that there will be a certain waste of food, that is to say, that the amounts registered in a dietary will be somewhat in excess by a certain amount of offal, of the quantity actually consumed.

The same may be said of the nitrogen, namely, that the amounts given in the table as remaining for growth, exhalation, &c., are much more than sufficient to meet the exigencies of the former, and they bespeak, indeed—so far as the figures can be taken as a true representation of the facts—a considerable gaseous exhalation or loss to

the manure of that valuable element. The proportion of the loss to the excrements by growth and exhalation, as indicated by this method of computation, is seen to be for the average of males about 20, for the average of females, 22½, and for the average of both sexes, and all ages, about 21 per cent. of the amount of nitrogen estimated as supplied in the food. This loss, as has been before stated, is only about half that found in the direct experiments of M. Barral. It is worthy of remark, however, that the amounts of loss indicated by our method of calculation agree much more nearly than those of M. Barral, with the determinations of the same kind made by M. Boussingault, and at Rothamsted, on the lower animals. It should be remembered, too, that the conclusion arrived at by MM. Regnault and Reiset, from their experiments on the gaseous products of the respiration of small animals was, that the proportion of nitrogen exhaled to that of oxygen consumed, seldom amounted to 1 per cent. Now, supposing we assume half this proportion of nitrogenous exhalation to represent the average, this would amount to about 1·46 per cent. of nitrogen evolved to 100 of carbon expired, on the supposition that 9·10ths only of this consumed oxygen are evolved as carbonic acid. And if we further suppose that there will be 1·5th more carbon in the food than is exhaled, and that, as indicated in our dietary tables, the proportion of nitrogen to carbon in the food, will be 5·5 per cent.—this would give us an exhalation of 22·14 per cent. of the total nitrogen consumed in the food—an amount, it will be seen, which agrees very closely with the indications of the table. It is true that our computations of the average quantity of nitrogen consumed in food, and voided in excrement, are not deduced, like those of M. Barral, from experiments as to both, made on the same individual at one and the same time. Yet the results we have brought to bear on these points are so numerous, and the confirmation of them afforded by other considerations is so striking, that we are inclined to adopt the view more favourable to the quality of the sewer water.

After this full discussion of the nature of the evidence at command for the estimation of the composition of the excrements of a large mixed population, let us see what are the results to which it has brought us. In Table VIII. is given at one view an abstract of the results more copiously stated in Table VI.

TABLE VIII.

Showing the Estimated Constituents of the Human Excrements of London.

Constituents.	Ounces per head per day. Average of both sexes and all ages	Pounds per head per annum. Average of both sexes and all ages	Tons per annum. Total for both sexes and all ages
Total dry substance.	2·01	45·95	51,286½
Mineral matter	0·45	10·34	11,536½
Carbon	0·74	16·85	18,809½
Nitrogen	0·35	7·94	8,859½
Nitrogen=ammonia	0·42	9·64	10,758½
Phosphates.	0·20	4·58	5,108

The average amount of real dry substance voided in the excrements of each individual of the population in 24 hours, is thus seen to be only two ounces; or equal to about 46lbs. per annum. This 2 ounces of dry substance will contain rather less than half an ounce of mineral matters, and the annual amount of these per head will be about 10½lbs.; and about ½ths of the mineral matters voided, or about ½th of the total dry substance will be phosphates. Of carbon in the excrements, there is about ¾ of an ounce per head per day, equal to about 17lbs. per annum. Of the valuable constituent nitrogen, there is an average of rather more than ⅓rd of an ounce per day, or about 8lbs. per annum; and these amounts of nitrogen

are equal to .42 of an ounce per day, and nearly 10lbs. per annum of ammonia.

The amount of the constituents voided by the total population in one year, if entirely freed from water, is seen to be 51,286½ tons. Of this about ¼th is mineral matter; and the *nitrogen* it contains amounts to about ¼th of the whole, namely, 8,859½ tons, which is equal to 10,758½ tons of ammonia. Now little more than ¼ a cwt. of ammonia is the usual artificial dressing for an acre of cereal grain, and it might be calculated to yield an increase of crop of 10 to 12 bushels of wheat, or this 10,758½ tons of ammonia would afford a produce of about 600,000 quarters, if it could be conveniently applied for such a purpose. The intrinsic value of the sewage of London considered in this merely chemical point of view is therefore enormous. Indeed, according to the above supposition, it would return to the metropolis nearly one-third of the wheat consumed by its population. If, however, it were thus devoted exclusively to the growth of corn, it would, at the rate above mentioned, extend over more than 400,000 acres of land. But this ammonia in the sewage of London is unfortunately distributed through an enormous bulk of water, and Mr. Wicksteed has shown us how immense would be the cost of distributing this material over any enormous area of land in the liquid form.

This leads me to a consideration of Mr. Wicksteed's alternative of a solid manure; and also to a closer calculation of the amount of fluid through which the manurial constituents which have been named are distributed in the metropolitan sewage. And, I shall endeavour to show, that for other purposes much more needed than corn-growing, in the immediate neighbourhood of a large city, the area of land over which such an amount of fluid, and such amounts of manurial constituents may be employed, can be very considerably reduced; so much so, indeed, that whilst I consider the application over so large an area quite impracticable, I am of opinion that the fluid might be applied over the more limited one, at a cost which would be small compared with the vast sanitary objects, and other advantages which are in view.

MR. WICKSTEED'S PROCESS.

Last year Mr. Thomas Wicksteed was requested by the Metropolitan Commission of Sewers to furnish a report upon a process patented by him, for obtaining a solid manure from sewage. This report is very ably drawn up, and gives estimates of the expence of carrying out his process for the London districts, and it also includes calculations to show the impossibility of employing such a large amount of liquid profitably by irrigation. As I am compelled to differ from Mr. Wicksteed as to the applicability of his process, and as he states that it would require a capital of one million to apply it to the metropolitan sewage, I feel that a few remarks on his data and calculations will not be out of place. Mr. Wicksteed's method consists in adding a certain quantity of lime to the sewage, by which the insoluble and suspended matters, and also some small portion of those in solution, are carried down in the form of a liquid mud. This mud, after proper subsidence, is removed into a centrifugal machine, by the rapid revolution of which a certain portion of the remaining water is thrown off. The manure is afterwards further dried by exposure to a current of air in sheds. The value of this solid product Mr. Wicksteed estimates at from £2 to £2 13s. per ton. He does not, however, give any analysis of it, and consequently the Commissioners have not the means of judging how far this estimated value is justified, or whether it is subject to correction.

I have already shown you how entirely the value of a manure must depend upon its containing certain ingredients, and that it is useless to attempt to put a value on any manure irrespective of its composition. I will, therefore, now inquire, first, what would be the chemical composition of such a sewage manure?—and secondly, what would be its probable money value?

Mr. Wicksteed has stated in his Report, that although the manure he had sent out, owing to some irregularity in the manufacture, contained 60 to 70 per cent. of water, it would, when properly prepared, contain only about 20 per cent. Now, to this 20 per cent. of water must be added the lime employed to precipitate the sewage matter. His calculation is, that 47,631 tons of lime will be required for the whole sewage of London, and that this will yield a produce of 220,451 tons of manure. Thus it would contain about 21½ per cent. of lime, and as the lime when mixed with the sewage, would for the most part be converted into carbonate, we must add 16½ to the 21½ of lime, which would give us about 38 per cent. of carbonate of lime or chalk. Chalk and water will, therefore, constitute about 58 per cent. of the manure. It is not difficult to estimate the composition of the remaining 42 per cent. It can contain but a very small portion of the ammonia of the excrements, for 8 or 9 tenths of the whole of this would be perfectly dissolved in the water; and it is well known to chemists that the addition of lime will not precipitate ammonia from solution. Almost the whole, therefore, of this, the most valuable constituent of the excrements, will remain in some form or other in the liquid. It cannot, either, contain much phosphoric acid, because the amount of this in the total sewage would be but small in proportion to the sedimentary matters, and to the chalk and water of the manure so made. This remaining 42 per cent. must consist, therefore, of a small quantity of organic matter, with sand and clay, together with some little sulphate of lime or gypsum, and a very insignificant amount of the alkalies potash and soda.

But we are not left to conjecture merely, as to the composition of a sedimentary sewage manure, such as that which would be the result of Mr. Wicksteed's process. Professor Way, in his valuable paper upon the composition of sewage, published in the Journal of the Royal Agricultural Society of England, has given us three analyses of manures made by adding charcoal and lime to sewage water, and in none of these does the ammonia amount to 2 per cent., whilst the average amount of phosphate of lime is less than 5 per cent., equal to about half that quantity of phosphoric acid. Yet the manures yielding these results were analyzed in a much drier, and therefore more concentrated state, than it would be possible to produce them on the large scale. The quantity of chalk amounted to from 30 to 40 per cent.; but as charcoal as well as lime was employed in the manufacture, the proportion of chalk in the manure would be less than by Mr. Wicksteed's process, in which lime alone is used. Mr. Herapath, of Bristol, has, however, published an analysis of manure made from sewage by lime alone. He states that it is prepared by the prisoners in Cardiff gaol, by adding lime-water in just sufficient quantity to precipitate the fecal matters from the sewage. When stove-dried, so as to contain less than 5 per cent. of water, the amount of ammonia was only 1½, and that of phosphoric acid only 2 per cent. The remainder consisted of nearly 70 parts chalk, about 3 of gypsum, some insoluble siliceous matter, and about 16 of organic substance, in which latter was contained the small amount of ammonia or nitrogen above mentioned. This analysis of the Cardiff manure agrees very closely, in all essential points, with those of Professor Way—the chalk in the former being about equal to the charcoal and chalk in the latter. Mr. Herapath remarks, that his analysis shows about three times as much nitrogen or ammonia in this manure as there is in farm yard dung; but it may be observed, that if farm-yard manure were dried to the same extent as the sewage compost, it would in that state contain as much ammonia as the latter.

In the following Table (IX.), is given a summary of these analyses by Mr. Way and Mr. Herapath; and by their side a column showing what constituents would be supplied in a ton of the lime-produced manure, if it contained 20 per cent. of water, as supposed by Mr. Wick-

steed; and in the fourth column, for the sake of comparison, is shown what is the per-centage of nitrogen, phosphates, &c., in the pure dry substance of mixed human excrements.

TABLE IX.

	Mean of 3. Way.	Made with lime only. Herepath.	In 1 ton lime sewage manure with 20 per cent water.			Dry human excrements.
			cwts	qrs	lbs	
Water	4.6	4.7	4	0	0	...
Organic matter (chiefly charcoal*)	*30.4	15.9	2	2	0	77.5
Earthy phosphates	4.7	4.1	0	3	0	9.9
Other mineral matters. {	Carbonate lime (with magnesia)	38.0	69.3	11	2	0
	Oxide iron and alumina	2.3	...	1	1	0
	Siliceous matter	12.4	2.7			
	Sulphate of lime	6.7	3.3			
	Alkaline salts	0.9	a little			
						12.6
	100.0	100.0	20	0	0	100.0
Nitrogen	1.4	1.12	0	0	21	17.3
Nitrogen = Ammonia	1.7	1.36	0	0	26	21.0

Such, then, are the constituents which it may be calculated would be contained in 1 ton of Mr. Wicksteed's sewage manure at a cost of £2, this being the price upon which he bases his estimate of 22 per cent. profit upon a capital of 1 million. Now, as I have already said, my farm is situated 25 miles from London, and the cost of bringing from thence 1 ton of manure is 15 shillings. But before purchasing any manufactured manure, I should sit down to calculate at what price I could purchase the constituents it contained? I find 1½ cwts. Peruvian guano would supply all the nitrogen or ammonia, and the phosphoric acid of such a sewage manure; 3 or 4 cwts. of rotted straw would supply all its organic matter; and the residue I could obtain from the chalk and sand pits. Thus, for about 25 shillings, I could bring upon my land the constituents of a ton of this manure, and for 30 shillings less money. Again, to supply the amount of ammonia put upon the experimental plot No. 16 in 1854, I should require nearly 7 tons of the sewage manure at a cost, including carriage, of about £19. I could obtain the same amount in 7 cwt. of sulphate of ammonia, at a cost of £5. Such, then, is the nature of the facts which lead me to the conclusion, that a *sedimentary sewage manure* cannot be profitably made by Mr. Wicksteed's process, or, I may add, by any known process.

Compare this composition and rate of value of a sedimentary sewage manure, with those of pure and dry human excrements, as given in the fourth column of the last table. Supposing it were possible, which it certainly is not, so to separate the constituents from sewage, as to get a manure of such a composition as this, there is no doubt it would sell for about £15 per ton; and since the excrements of each individual of the population contain in one year 46 lbs. of such dry substance, it would take 48 persons to produce 1 ton of it per annum; and this would give an annual value of about 6 shillings for the excrements of each person; and at these rates, the total value of our 51,635 tons of dry substance contained in the excrements of the total population of the metropolis, would realise the sum of £774,525. And even assuming that it could be obtained, mixed with its own weight of water and the extraneous solid matters of sewage, it would still contain nitrogen equal to rather more than 10 per cent. of ammonia. Such a manure as this would bear cost of carriage to a considerable distance, and would be worth but little less than half as much per ton, as the unmixed dry excrements. The mixed solid and liquid excrements, in the condition in which they leave the body, contain as much as 94 or 95 per cent. of water, and it is possible, that in that state it might be profitable to evaporate or otherwise manufacture them into a solid manure;

even then, however, it would require 16 or 17 tons of fresh excrements to produce 1 ton of portable manure. But it is not thus that we have to deal with them in sewage; there can be little doubt, that as so diluted, about 9-tenths of their most valuable constituent nitrogen, will be perfectly dissolved in the water, and will remain so after the separation of a sedimentary manure by any process known.

Considering, then, the profitable manufacture of a solid sewage manure quite impracticable with our present knowledge, I now turn to the question of the employment of sewage in the liquid form by irrigation; and I will first make a few remarks on Mr. Wicksteed's elaborate calculations on the cost of distributing the sewage of London in this manner. When I tell you that he estimates the capital required for this purpose would be nearly twelve millions, and the area over which it would extend at 3,500 square miles, or more than two million acres, I need hardly say that, unless some error is to be found in his estimates, the employment of sewage by irrigation is altogether impossible.

I think that such an error does exist, and, as it occurs at the basis of his edifice, it materially affects the whole superstructure. Mr. Wicksteed founds his calculation upon a supply of 150 tons of sewage to an acre of land annually; and on this point quotes the authority of the late Mr. Smith, of Deanston, who estimated from 80 to 160 tons as a proper quantity. This 150 tons of sewage is estimated to contain 6 cwt. of solid matter; the calculation being made from the analysis of Professors Brand and Cooper, who found one part of dry substance in 500 parts of sewage. This analysis, however, was made some time ago, when the supply of water was supposed to be about 20 gallons per head daily; but Mr. Wicksteed has founded his other calculations upon a supply of 36 gallons, which would, of course, reduce the estimated quantity of solid matter in 150 tons of liquid, by nearly half. Now, 36 gallons per head per day is about 60 tons per head per annum; so that the excrements of 2½ individuals only of the population, would be supplied to each acre of land, and the amount of dry substance contained in the excrements of these 2½ persons would be rather less than 1 cwt. It would be obviously little less than absurd to be at the expense of laying down pipes to supply an acre of land with such a minute quantity of sewage matter as this. You cannot call a field irrigated which receives, in the course of a year, little more fluid than might fall upon it in one day's rain. If sewage is to be turned to any profitable account, it obviously cannot be by sending a pipe into Oxfordshire, another into Bedfordshire, into Essex, and into Surrey, and selling it out by the gallon, as you would ale or porter. So far, then, I quite agree with Mr. Wicksteed, that if the area of land he supposes be required, it is quite impracticable so to apply the metropolitan sewage.

With regard to what is, probably, the amount of fluid that would have to be disposed of, in dealing with London sewage, I will say a few words. By a return presented to the Houses of Parliament last July, it appears that the water delivered into the metropolis by the nine water companies, gives an average of from 24 to 25 gallons per head per day on a population of 2½ millions. I find, also, that the average fall of rain over the area supplied by the water companies will give almost exactly a similar amount per head, namely, between 24 and 25 gallons. The supply of the companies and the rain-fall taken together, therefore, give a gross amount of nearly fifty gallons per head per day. But, from this a considerable portion must be deducted for evaporation. Mr. Wicksteed estimates, however, that the supply of the companies will very shortly be 36 gallons per head; and, as there is no doubt that they are preparing generally to increase the present amount, I am inclined to think that, by the time any comprehensive scheme for the disposal of the London sewage can be brought into

operation it will not amount to much less than 50 gallons per day for each individual of the population.

Fifty gallons per head per day would amount to 8½ tons per head per annum, and, as it has been seen that the dry substance of the excrements of one individual is 46lbs. per annum, it follows that a ton of sewage would only contain 9 ounces of these excrementitious matters. It is not to be wondered at, therefore, that when lime, sulphate of alumina, or other matters are added to sewage, it should run off from the sediment clear and tasteless. It may do so, and still retain, as undoubtedly it does, almost the whole of the most valuable constituents of the excrements. On this point it may be remarked that Mr. Wicksteed states, that the lime process does not act properly when the sewage is not very dilute; and I myself noticed last year, that the sewage, after being submitted to Mr. Stoddart's process, had a strong urinous odour.

In conclusion, there can be little doubt, that if the sewage of London is to be turned to some useful purpose, it must be applied in the liquid form in such quantities as to yield the greatest possible growth that land and season are capable of. And, certainly the enormous amounts of produce of Rye-grass, which have lately been recorded as the produce of irrigation, and which there is no reason to doubt—were never obtained by such small amounts of liquid as the late Mr. Smith, of Deanston, supposed sufficient.

For corn crops an enormous supply of liquid manure is certainly not well suited, for the influence of season fixes an easily reached limit to the produce of grain, the gross value of which cannot much exceed £12 or £14 per acre. For market gardens, again, liquid sewage does not seem well adapted, as with its use the surface of the land is liable to become crusted, which is injurious in the growth of the vegetables. There is, however, another objection to any extensive application of sewage to this purpose, in the unlimited amount of good stable manure which is easily carried back by the carts which convey the produce to London. It could, moreover, be easily shown, that the dung which was so comparatively inefficient a manure for the growth of wheat, is, nevertheless, peculiarly adapted for the production of vegetables.

I return, therefore, to *grass* as the most suitable crop for the application of liquid sewage. But that its use, even for this purpose, should be attended with advantage, it must, as I said before, be employed in the most liberal quantities that the capabilities of land and season will admit of; and, in this way, it is not impossible that in the neighbourhood of a large city a rental of £20 to £30 per acre might be obtained. Experience alone can decide what is the minimum area of land which would yield the maximum produce and rental from the sewage of London, but there can be little doubt that it would require many thousand tons of sewage per acre to yield the rental I have supposed. I may mention, however, that if 10,000 tons of sewage were annually applied to each acre, it would take about 20,000 acres to absorb the whole sewage of London, upon the estimate of 50 gallons per head per day. But it is even possible that so far as the quantity of liquid is concerned the area might be reduced below that which is here assumed. It will be said, perhaps, that such an amount of sewage is much more than would be usefully applied in furthering growth, or even that it would be wasteful or injurious. The point, however, to which I wish particularly to call attention is, that up to the limit at which either the amount of liquid or of manurial constituents becomes positively injurious, an apparent extravagant supply of ingredients on a limited area of land, will, there is little doubt, yield a more profitable result than a saving of manure with a more extended area.

There would surely be no great difficulty in appropriating a few thousand acres at no great distance from the Thames to the purpose in question. And grass being the produce grown, so milk and cream should be the chief products obtained in return. Irrigated grass appears to

supply food peculiarly adapted for the production of milk; and there are certainly few articles with which the inhabitants of the metropolis are so inadequately supplied. Whilst, therefore, they must be justly charged for the removal of the sewage on sanatory grounds, they might surely demand, that the cost should be lessened by a proper application of the sewage; and it appears to me, that a liberal distribution of it on grass, is the most promising means of attaining this result.

DISCUSSION.

After the reading of the paper, Mr. P. Le Neve Foster, the Secretary, stated that he had that morning received a communication from

Mr. T. WICKSTEED, who, after regretting his inability to attend the meeting, proceeded to say, "I am now enabled to say that I feel assured a few weeks will see the completion of our works at Leicester, and then we shall be prepared to make and continue making quantities of manure sufficiently large to enable practical agriculturists to give us practical opinions, which, with all respect, and great is mine, for chemists, I shall consider in a commercial point of view, the best test of the value of the manure we propose to supply. In saying so, it must not be considered that I am undervaluing in any degree the labours of the practical chemist, to whose advice I owe so much, but I was warned both by a late great chemist and one now living, that after all their analyses, useful as they were in affording me the information which determined me and my coadjutors to undertake this great work, its value at last would have to depend upon the test the agriculturist would put it to, for although in a manure like guano, with certain predominant salts, analysis would directly detect the true from the adulterated article, and very accurately determine its value, nevertheless, in one containing most of the valuable fertilising salts, but in which it appeared that none were in unusual excess, although there could be no doubt of its value, the extent of that value would depend in a great measure upon the price at which it could be offered to the farmer, and also at which it could be made so as to yield a sufficiently remunerative profit to the manufacturer. The result has hitherto shown in this, as in other instances that might be mentioned, that the prognostications of these gentlemen were correct. We have made during the last two years, at our Experimental Works, about 100 tons of manure in different stages of dryness; the last has been as dry as guano, containing from 20 to 25 per cent. of moisture; in this state if left in heaps it *heats*, and this, although a very good practical test of its goodness, is disadvantageous where large quantities are made; it is, therefore, proposed to keep it in damp solid heaps, and, as wanted, to spread it and let it dry, as we have proved it will do upon floors, without the necessity of using artificial heat, which might reduce its value. I have but few reports of its value which at present can be placed before men of science, because all the conditions as to area manured, as to the cost of the manure with which it was compared, and other data, have not been properly attended to or recorded—but in two instances, with different crops and in different soils, and under different conditions of weather, the results were, in the most unfavourable instances, a value of 53s. 4d. per ton as compared with guano, and in the other 130s. per ton, making an average, not, however, one to be relied upon, as they were both probably extreme cases, of £4 11s. 8d. per ton. Now we have proved, in our practical trials during the last two years, that we can manufacture it upon the large scale for less than 20s. per ton, and, therefore, 35s. or 40s. per ton would pay for the outlay, and if this be the case, there can be no doubt, that out of very dilute sewage a sufficient quantity, although not amounting to above ¹/₁₀th part of valuable matter, may be extracted at such a cost that it will pay the manufacturer. But although to those who are risking

thousands upon these works the question of remuneration may be most important, nevertheless, that of being enabled to disinfect the sewage water of any town, is one that I consider our experiments have settled for ever, and that if it did nothing more than pay the community who adopted the process, it would be a great public benefit; but I am entering into matters which I intended, and wish to abstain from entering into for a short time longer. As far as my own experience is concerned, and I have sacrificed much of my professional business for the last few years in working out the question, I have no doubt of being able to show that the sewage of towns may be reduced not only innoxious, but may be converted into a profitable and most useful article of commerce, and especially as a stock manure. Before concluding these remarks, which you are at liberty to use as a whole, in any way you please, but not to extract from, I may state that we are providing works for a population of about 100,000, looking to the future increase of Leicester, at present having a population of between 60,000 and 70,000—that our pumping engines are of about forty horses power, and our machinery engines about eighty horses power—we have five engines in the whole—that our reservoirs in duplicate are together equal to an area of less than half an acre, and are under cover—that we have at work two large agitators for lime, twenty agitators for mixing the lime and sewage, two screws for removing the precipitate from the bottom of the reservoirs, two Jacob's ladders for raising the sewage up into eight centrifugal drying machines, with space prepared for as many more, and that all these machines have been at work, with very slight exceptions; and that we expect the whole to be in full work before the end of this month, there being nothing more required than the many slight matters of adjusting, strengthening, &c., which are consequent upon the first starting of all new concerns. Whether you may think it worth while to read this letter or not, I do not know. I, however, beg leave to remind you that, as far as I am concerned, I am not desirous of having any discussion upon our works until they are complete; at the same time, I could not but respond to your second appeal, although in the foregoing imperfect manner."

Mr. SIDNEY, in the name of the agriculturist interest, warmly thanked the Council for the admirable paper on the very important subject which they had been the means of inducing Mr. Lawes to read. Mr. Lawes was not a mere chamber student—for a long course of years, on a very large scale, he had conducted experiments at his farm, which had already been of essential service to agriculture; indeed, a testimonial of no mean value had recently been presented to him by the united subscriptions of practical agriculturists, as a testimony of their sense of the value of his contributions to their special pursuits. It needed the investigations of such a man to draw the serious attention of those who lived by farming to the question of London sewage—a subject on which, within the last ten years, tons of volumes, and whole rivers of speeches had been circulated by sanitary reformers, most enthusiastic on town cleansing, but very insufficiently endowed with the scientific acquirements or habits of correct observation essential for affording intelligent advice to tenant farmers. In the sanitary Blue Books, he (Mr. Sidney) found the same examples of success on a small scale, under circumstances which had very little relation to farming, repeated again and again. He would therefore take the opportunity of giving some account of the irrigation by sewage water in the neighbourhood of Milan, conducted by Lombard farmers, of great skill, with the aid of the accumulated hydraulic science of two centuries. These operations and their results, satisfactory as they were in that climate, in an agricultural point of view, were very far from bearing out the views of the two gentlemen, Mr. Mecchi and Mr. Edwin Chadwick, whose names were best known as advocates of the employment of steam-engines and pumps, and miles of pipe

for the distribution of London sewage. These gentlemen attempted to justify the enormous expenses, incident to establishing and working machinery sufficient for pumping and delivering the sewage of London at long distances by exaggerating the fertilising qualities of sewage, by asserting that it would supersede all portable manures, and by maintaining that liquid manure was in every respect superior to solid manure; and they supported these theories by extremely under-estimating the operations needful for distributing the liquid where it was most valuable. On most of these points Lombardy afforded a complete contradiction. But in order that he might not be accused of misrepresenting Mr. Chadwick and Mr. Mecchi, he would refer to speeches recently delivered by them on this question at the Farmers' Club. In the first place, as to the abstract value of the London sewage, Mr. Mecchi intimated, although he did not positively assert, that its value far exceeded £250,000 a year. He compared the loss of sewage to the loss of so much Peruvian guano, and he concluded by asserting, on the strength of his Tiptree experience, that liquid manure was applicable and preferable in the cultivation of corn crops and root crops—that in fact, it was equally available "to all crops and to all soils." Mr. Chadwick had followed, at the Farmers' Club, in the same vein; he had quoted the old example of Edinburgh, which the shrewd Scotch farmers had not ventured to imitate; he had proposed to substitute steam-power with a jet and rain shower of sewage for water meadows, by which he promised to get rid of the poisonous nuisance of water meadows; and he illustrated the superiority of liquid manure over solid for cereal and all other crops, by telling an old story of an American who grew some large vegetables with liquid manure manufactured in a hogshed, and distributed in a watering-can. All this sounded very plausible in the ears of those who knew nothing of farming operations, but in sober truth, it was a mass of exaggeration on a small substratum of limited experience. Mr. Lawes had well shown that all comparisons between so unwieldy, bulky, and volatile a substance as sewage, with concentrated manures like guano, were absurd. Liquid sewage occupied at least thirty times as much bulk as guano; guano was easily stored and easily distributed. It was a mere rhetorical artifice to compare human beings as manure manufacturers to sheep who carried the manure on the land. The members of the Society of Arts were no doubt familiar with specimens of Canadian copper ore which contained thirty, forty, and fifty per cent. of metal, and excited ideas of unbounded mineral wealth in the minds of speculators, until it was discovered that the cost of carriage over some hundreds of miles of mountains would entirely consume the value of the ore. Of the same character were comparisons drawn between the results of sewage applied to farms thirty miles from town and experiments out of a hogshed on the lawn of a sewage commissioner. Italian experience was equally against the total substitution of liquid for solid manure, and the substitution of Mr. Mecchi's artificial rain for the water-meadow system of Edinburgh. At Milan, for 30 years the sewerage had been under the care of a regularly-constituted commission, which levied a universal graduated tax on every house, shop, manufactory, and stable, for the privilege of access to the covered rivers, which, flowing beneath and around the city, formed main sewers, like our large intercepting sewers. For the use of this sewage water a limited number of persons paid a rate equal to 20s. an acre, and the results they obtained from its use under the Lombard climate were certainly extraordinary. The fields were laid out as water meadows, on the plan of irrigation which was so well understood in Italy. To adapt the land it was levelled and sloped, provided with main channels and drainage ditches. It was sown exclusively with one-fourth red clover and three-fourths Italian ryegrass, and during the months of June, July, and August a continuous unbroken film of sewage water was poured over it without cessation, except at the time of cutting, after the

rate of from two hundred to three hundred and ninety tons per acre, in the 24 hours. The result was the most valuable description of "marcite" or winter meadows for stall feeding cows in the great dairies near Milan. The meadows were mowed four times, that was to say, in November, in January, in March, and in April, for stable feeding. In June, July, and August, three crops of hay were secured; in September, the cattle obtained a month's abundant pasturage. Thus, the "marcite" meadows, irrigated with sewage, were made to yield from 45 to 50 tons of Italian rye grass, and, under extraordinary circumstances, half as much more. But these satisfactory results were confined to a limited space. It was the opinion of the Italian farmers that liquid manure was injurious to all cereal crops, except Indian corn. In a vast territory of irrigation, the whole extent of "marcite," or winter meadows, was under 15,000 acres, and of that extent only a few were under liquid sewage. To summer crops the Italians were careful only to apply liquid manure immediately after cutting grass; at any other time they considered that it burned up the crop. Although they had the means, in their perfect irrigating arrangements, of turning all their solid manure from their great dairy stalls into liquid manure, they adopted the reverse course. They collected from Milan, scraped from ditches, and gathered in stables, great heaps of solid manure, which they distributed over the land weeks and months before water irrigation commenced, after the rate of as much as twelve tons to the acre, thus proving that, with experience of both, they found both useful. These interesting details on Italian irrigation he (Mr. Sidney) had extracted from a laborious work by Lieut. Baird Smith (Madras Engineers), who had been sent to report on the subject by the East India Company. Allowing for the difference of climate, it was certainly more to be relied on than the small experiments to which attention was so often called by the enthusiasts in sanitary reform. On the subject of cereal cultivation, he (Mr. Sidney) certainly preferred the opinion of the farmers of Lombardy and Piedmont to that of his enthusiastic friend, Mr. Mech. It must be remembered that Tiptree had been most lavishly cultivated and manured long before the pipe and jet system had been laid down on it. It had been deep drained—subsoiled, ploughed, cross ploughed, hand-forked at an enormous expense; for several years Mr. Mech had been content to take for his share of profit a large stock of solid manure; if then, in 1853, when every good farmer had a bountiful corn crop, Tiptree was equally blessed, it would be rash, however pleasant, to assume that all this arose from the use of liquid manure. In any event, Mr. Mech's liquid was very different stuff to sewage pumped and tritured through fifty miles of pipe. In conclusion, he had no doubt that, under favourable circumstances, sewage manure had a certain value for grass crops, if it could be applied on the water meadow system, by tons at a time, but he strongly recommended his agricultural friends to conduct their operations under the advice of men of science and practice, like Mr. Lawes, and to obtain their engineering estimates from engineers of acknowledged character and capacity, not to be led astray by the brilliant visions of sanitary reformers, who saw a very Pactolus in every street sewer.

Mr. CHADWICK said the last speaker had couched his observations as if he (Mr. Chadwick) had made extravagant representations of the commercial value of sewer manure. Now, the following were the words of the Minutes of Information officially promulgated: "In respect to the money value of town manures, where payment is made for their removal (as in the majority of town districts) they cannot properly be said to have any money value whatsoever, their intrinsic value, 'that is to say, their power as fertilisers,' being counterbalanced by the labour and inconvenience of collection, removal, and application, and by their restriction—in consequence of that expense of removal—to a narrow field of application, and comparatively small

market; but, in proportion as the labour and consequent expense of collection are reduced, and the conveniences and certainty of the application of these manures are increased—as they will be by systematised works, which may be substituted under the Public Health Act—their money value will be increased, as compared with other manures, which at present are more convenient for use." With such facts as he had displayed in 1842, of contract prices of one pound per house being paid, on the average, in the metropolis, for emptying cesspools, that is to say, for the collection and removal of the most powerful fertilisers, it was then demonstrated, as now enunciated in the paper which had just been read, that the cost of carriage regulated the price of manure. Abounding, as the metropolis was, in those fertilisers, it was then shown that their use was restricted to an area of a very few miles, seldom exceeding ten miles, by carts returning loaded with manure after the sale of produce in the markets. At Liverpool, and other towns, where the farmers had begun to pay for the collection of night-soil, that is to say, for emptying cesspools, this extent of demand for it was discontinued on the introduction of guano, and of such new manures as the one of which the gentleman who read the paper was so large and prosperous a manufacturer, namely, phosphate of lime. Why was this, but on account of their superior portability, and, also, on account of their comparative convenience of manipulation within the farm. The English farmer commonly had not attained skill in the manipulation of town manures, or in overcoming their offensiveness, or in dealing with their bulk. The Belgian farmer had got the idea of liquifying them, and some skill in applying them by the means of the water cart, comparatively expensive and cumbrous as it was; and in Belgium there was a demand and a price for the town manures in question. Mr. Lawes had stated that, his farm being situated at 25 miles from London, the cost of carriage from London upon one ton of manure was 15s., and reasoning only upon the conveyance of the solid manure, he said that from such data it was not difficult to decide the actual and relative values in a practical point of view of the chief elements of manures. No doubt from such data; but he had wholly ignored the engineering data, which fifteen years ago he, Mr. Chadwick, had submitted of the power gained by steam for the removal and application of town manures, in suspension, in water, and pipe distribution. In the sanitary report then published, he had called attention to the fact, that even London water companies conveyed and sold with a profit, 12 or 14 miles, and raised to heights of 150 feet, water at two pence half-penny per ton. Practically sewer water did not, as regarded this power of conveyance and distribution, differ from the river water. Indeed, at times of floods, the Thames water, unfortunately for the consumers, in the quantity of land surface washings and matter carried in suspension, did not differ from sewer water. Adopting the data, as to actual practice in pipe distribution, the late Mr. Smith, of Deanston, in conjunction with an engineer of one of the largest London water companies, had shewn that sewer manure might be raised over heights, and delivered with a profit to farms twenty miles distant, at two pence per ton. In various parts of the country, with small companies as well as large, three pence per thousand gallons was a common price for the conveyance of water considerable distances, and its delivery into manufactories. And the same might be done with farms, of course with the like extent and constancy of demand. The same principle which he had demonstrated, that for manures there was no mode of conveyance so cheap as pipe conveyance in suspension or solution in water, was applicable to the conveyance and manipulation of manures within the farm itself. Look, however, at its application to the case Mr. Lawes had presented of his own farm, twenty-five miles distant. Why, for the cost of carrying one ton of solid manure, no less than seventy-two tons of sewer manure, equivalent to three or four dressings for an acre, might be

carried thither. In the Minutes of Information on the application of the manures of towns, a demonstration of actual practice was displayed. In the instance of Mr. Kennedy's farm at Myer Mill, Ayrshire, where the principle of liquifying the solid manures had been adopted, some of the pipes radiated from the farm-stead more than a mile, and it was shewn that the expense of pipe distribution from such extremities, and giving a dressing of two hundred pails full, or between two and three hundred gallons, was under one penny. This engineering element of pipe distribution, now gave liquid or sewer manure the advantage not only over such cases as had been cited of solidified manure, but over the most portable manures, even guano itself, if it were applied in the solid form. Whilst Mr. Lawes failed in omitting to notice the evidence, of the practical operation of the economies and facilities for the distribution of the manures of towns, in his synthesis, he also failed in the omission of large constituent elements of sewer manures, properly so called. Let him go down to the laboratory attached to his own house—his kitchen, and observe the operations of his cook, her boilings of vegetables and meat, her solutions, her skimmings, her dish-washings; let him consider, too, the soap used in washing his person and the persons of his household, and in washing clothes and floors, and all other things carried away in the water used for domestic purposes, and he would find how large had been his omission from the constituent parts of sewerage from within the house. So large were often the quantities of fatty matters discharged from houses into the sewers, that a project had been set on foot for collecting the fat in sewerage, and making it into candles; and he (Mr. Chadwick) had been presented with candles made from the fat precipitated from sewerage. Whilst the constituent proportions of sewage from within the house were reduced by the omission of matters cognizable everywhere by domestic observation, the statements which had been referred to as authoritative, widely exaggerated the extent of necessary dilution, when it was stated at fifty gallons and even twenty gallons per head per diem. Now the actual discharge of sewage from houses of the first class in the metropolis, which had several water-closets, and in which the use of water was complete and liberal, had been attentively gauged, and it was found not to exceed twelve gallons, or twelve gallons and a half, per head—or seventy gallons per house. Thirty pails full a-day would be found a large domestic use. For the poorer classes it would be less. From those gaugings it had been demonstrated, from the run of water on the days when the water was on, that, under the intermittent system of supply for which Mr. Wicksteed contended, three-fifths of the water pumped into the metropolis was distributed in worse than waste. With mismanagement of the apparatus the like waste might occur under the constant system; but the exaggeration of the bulk of dilution actually required had been proved to be double or even threefold. Then the synthesis omitted the constituents of sewerage outside the house, the soot from the roofs, which was to be seen running down from the gutters like ink, the dung of horses and animals, and the surface washings of the streets. These had been collected on days of rainfall and storm, and had been found by Professor Way to contain silicates and other matters, in actual quantity of matter in solution or suspension, without comparison of the quality, to exceed the sewerage derived from within the house. Indeed, much of the matter treated as examples of sewerage, had been found to consist mainly of the surface washings of towns. The last speaker had referred to the case of the Italian irrigations. He (Mr. Chadwick) had directed the attention of Captain Baird Smith to the irrigations of Italy as a source of experience available for India, and could speak of them. The instances of irrigation carried on for centuries were not, as might be supposed, except in the case of Milan, instances of irrigation with town sewerage, but instances

of agricultural irrigation with simple water; and, in the case of Milan it would be found that in the Palazza, or except, perhaps, some instance of an English hotel, water closets, or house drainage in our sense was unknown. Night soil might be collected and used in the solid form there, simply because there was no other mode of collecting and using it. The irrigation with the vegetable was mainly an irrigation with the surface washing of the city. The case of Mansfield was cited as an instance of irrigation with sewer manure. But Mansfield was a town of cesspools, with little or no proper house drainage, and the sewerage was chiefly the surface washing, which was most rich in days of heavy rainfall. Even the sewerage of the metropolis was far from being in a condition to reason from, and was not reasoned from by those who had considered the subject. Seventy and eighty per cent. of the houses in populous districts were proved to be without water closets, and in the higher class of houses, the water closets themselves discharged into cesspools. The brick drains were commonly drains of deposit, as were the greater proportion of the flat segmental sewers of recent construction. The whole system of house and street drainage and engineering construction, as had been demonstrated, formed one system of extended cesspools. That which they smelt at the gully shoots, was the result of the decomposition of the matter retained in the sewer. Mr. Lawes, as a chemist, would admit that all that escaped by decomposition into the streets to the pollution of the common air was the loss of so much of the most valuable constituents of manure. The greater proportion of the metropolitan sewerage was the overflow from disintegrated and deteriorated deposit. Now, under the new system of pipe sewers, it was demonstrated that, where they were properly adjusted to the flow, by competent engineers, they were perfectly self-cleansing, there was no accumulation of deposit, no wasting of the manure by decomposition, no smell of decomposition in the streets or houses. They might now test the engineering or the administration by the smell. If there were any smell of decomposition from the new works, there was deposit, and if there was deposit or the need of flushing, even, there was default in the engineering. If they went to the outfall of the new pipe sewers laid down at Tottenham, which was now drained, as he contended every town ought to be drained, where even the poorest house had a water-closet, and where there were no cesspools, they would there, at the outfall, perceive that there was less smell from the sewerage discharged from sixteen hundred houses than there was from the uncovered cesspool of a single house, and that smell, not the smell of decomposition, as in the case of the cesspool. Under the new system, the excreta of towns was removed from beneath the site by a constant flow, at the rate of from a mile and a half to two or three miles per hour. Mr. Cuthbert Johnson, who had paid attention to the subject of the new conditions of sewerage, had shewn that ordinary house sewerage discharged by self-cleansing pipe drains did not enter into the stage of decomposition until about four days after its delivery. All the smells of decomposition from house drains or sewers were therefore generally smells from matter more than four days old. All the arguments from the experience of sewerage in old or the common conditions, even when derived from positive analyses were, therefore, fallacious when applied to the new systems of works, from which the applications of sewerage to agricultural production had been proposed. Instead of the constituent parts of sewerage (in addition to human excrements) being diminished with the progress of new habits and sanitary improvements, as Mr. Lawes had assumed, they would be increased in consequence of the superior economy as well as convenience, and comparative inoffensiveness of that method of removal. The data as to the extent of area requisite for the application of the sewerage of towns, appeared to have been as little attended to as were those in respect to its future composition. In his own report, in 1842, he (Mr. Chad-

wick) had stated: "If the increase of production obtained by the use of the refuse of Edinburgh (that is of 3900 oxen from one quarter of the refuse of Edinburgh), be taken as the scale of production by the use of appropriate measures, the refuse of the metropolis alone that is now thrown away would serve to feed 218,000 oxen annually, which would be double that number of acres of good pasture land." The case of Edinburgh was the best of which he was aware to serve as data, and that, it must be said, was the case of a wretchedly drained town. Now, the quantity of land on which a quarter of the sewerage, as near as could be ascertained, was applied, was not more than six hundred acres. At the same rate there would be required for the advantage of the metropolis about nine square miles, or a plot of about three miles square, or a belt of about a quarter of a mile broad round the metropolis beginning at its inner diameter five miles from St. Paul's. Compare this datum with the allegation of the requirement of 3,500 square miles for the reception of sewerage on the old principle? The only instance in which there had been any observations of which he was aware, of value in respect to sewerage in the new conditions as to drainage, were those of Mr. Cuthbert Johnson, who for several years had observed the application of the sewerage of his own house to a plot of land, and had analysed the soil water, and noted the products on grass carefully. On his scale 33 acres of land would be required to apply the sewerage of 1,000 persons to grass land. On the same scale, it would require 114 square miles, or a square of ten miles and a half, or a belt of little more than two miles for the metropolis, the inner margin beginning five miles from St. Paul's. But he obtained production only at the rate of twenty-two tons per acre,—which, however, was five-fold the production of his neighbours from the like land; whilst in Scotland, from more concentrated applications, they obtained sixty and seventy tons per acre. Mr. Johnson expressed his own belief, that one-third the area, or 38 square miles, might be made to suffice: and he, Mr. Chadwick, was led to believe that little more might be made to suffice with the addition of the surface washings of the town, which were not included in the observation. Mr. Lawes had spoken of sewerage as the best suited for grass lands. Now there was no warranty for this limitation. Sewer manure, and that of an inferior quality, had been applied to cereals and to every species of production in market gardens, and to and to all with complete success. Even in that of the highest agricultural production, gardens, where twenty pounds per acre in labour, and twenty pounds per acre in manure, had been accustomed to be bestowed, the range of the application of sewerage manure by the jet was displayed in the superiority of every species of vegetation. The sufficiency of Mr. Lawes' experiments in the growth of crops, or their applicability to the present subject, was to be denied. Those experiments, unless he (Mr. Chadwick) misunderstood, were made with solid manures? [Mr. Lawes expressed assent.] Just so. Mr. Pusey had, in a paper in the Royal Agricultural Society's Journal, stated some experiments as to the comparative effects of the application of guano by the old drill, or in the solid form, and the effects of the application of the same quantity of guano by the liquid drill, in the liquid form. He showed that the produce was double from the liquified manure. Mr. Pusey appeared to be amusingly unconscious that in that case he was giving the general case of liquified manures. In the Minutes of Information to which he referred, a case was stated of the application of liquified farm-yard manure for upwards of twenty years, during which a continuous fivefold production was obtained, whilst the highest dressings with the solid manures, only yielded an increase of one fold and a half on the same land. The proposed applications of liquified manures, were treated as novelties, whilst in a less convenient and economical form there was wide continental experience; and they had also the experience of the horticulturalists,

by whom the highest productions in weight and quality were obtained by that form of application. When it was proposed to restrict the application of liquid manure to one description of vegetation, it seemed to be forgotten that no one form of vegetation known did or could feed on manure in the solid form; whilst all vegetable physiologists agreed that moisture was necessary for the feeding of plants, it did not seem to be yet determined whether the matter of manures was not reduced to the gaseous form before it could be assimilated. The greatest vegetable physiologist of the last century, De Candolle, had pointed out that the course of agricultural improvement in Europe, would be giving to vegetation water and food at the same time. If the time permitted, much more might be observed upon the course indicated in Mr. Lawes's paper. He, Mr. Chadwick, had noticed, he thought, the chief points in which there had been serious misapprehension, or oversights of existing information.

Mr. ARTHUR MORSE wished to make a few observations on the quantity of sewage manure that could be applied to land in a liquid form by the process of pumping. Mr. Wicksteed and others had assumed, that the sewage of a town would fertilize land at the rate of $2\frac{1}{2}$ individuals to an acre. His (Mr. Morse's) experience, however, had led him to a conclusion of quite a different character. The value of sewage manure, he thought, was small, and that a very large quantity could be put on an acre. From his experience of the application of sewage water in the town of Swaffham, which had been tried since the introduction of the Health of Towns Act, he was of opinion that the sewage water from a population of 1,000 inhabitants could be safely put on an acre of land. The sewage of a part of the town of Swaffham had been applied to the land by the process of pumping, and the result was as follows:—The value of the land at the commencement of the operation, for gardening or building purposes, was £250 an acre. The reservoir and drains to connect the houses and streets with the land cost £200 more, and thus made £450 the cost of the acre. The annual rent of this acre at four per cent. would thus be £18 a year. Working expenses were found to be £10 a year more, and £10 a year was also charged for wear and tear and repaying outlay. The rent and expenses of the land were thus £38 an acre. Now for the profit. A careful weighing of each cutting of the Italian rye-grass in the year 1854, gave a quantity of 65 tons to the acre. This, at its market value of 15 shillings per ton, would be £48 15s. per acre, but the value of it to the owner was even greater than this, for the consumption of hay economised by it was to the owner 10 tons, at £6 per ton, or £60 per acre. If, as it was supposed in this case, that the sewage water of 1,000 inhabitants could be put upon an acre of land, the sewage of London, with its population of two millions and a half, might be got on to two thousand five hundred acres. Estimating it at £10 an acre, the annual value would thus be £25,000 a year. This was on the supposition that a great part of the solid manure of London was taken away, as at present, for garden and other purposes. On the whole, he thought the application of sewage manure by the pumping process was, on a small quantity of land, a very profitable undertaking, and on a large scale would be done at much less expense.

Mr. J. J. MECHI had only one word to say. He would express his deep gratitude to Mr. Lawes for the very valuable paper he had read, which added to the many claims that gentleman already had upon the agricultural community. Still he (Mr. Mechi) felt some regret that he had not put a sufficient value upon water alone supplied for irrigation. He would only call attention to the fact stated by Mr. Way, in the 14th volume of the Royal Agricultural Journal, in his paper "On the Constituent Properties of Grasses," namely, that the grass of meadows irrigated with water alone contained double the quantity of fattening, and double the quantity of albuminous

matter, compared with those which were not so irrigated. After that evidence he thought they were safe in considering that the application of water alone, of London, for grass crops, would be attended with very beneficial results. With regard to cereals from his own experience on the poor clay soil of his farm, he could say that the effect of applying solid manure in a liquid form had increased the crops to a very great extent, even as regarded cereals, and it also enabled them to do what most farmers were afraid to attempt, viz., to take off a crop of some 30 tons per acre of mangel-wurzel, and afterwards, as he had himself done last year, grew 13 quarters of oats per acre on the same land. He therefore thought they need not be afraid of cereals being too strong after having taken from the land a heavy and valuable root crop, such as he had mentioned.

Mr. F. O. WARD said that, at that late hour of the evening, and after the able and luminous remarks that had fallen from Mr. Chadwick, he should not detain the meeting with any lengthened comments on Mr. Lawes's paper, to the value and interest of which he was happy to bear his humble testimony. As, however, reference had been made by Mr. Lawes to the Metropolitan Commission of Sewers, of which he was a member, and as some proceedings of that body, and some papers laid before it, had been quoted as lending the weight and sanction of the Court of Sewers to a particular view of the question under discussion, he felt it his duty to say a few words on those points, to prevent misapprehension. Thus, Mr. Wicksteed's report, made at the request of the Commissioners, on the question, whether sewage should be applied in the liquid form, or whether its valuable ingredients should be solidified, was a document printed only for consideration, and must by no means be taken as commanding their general assent, still less as stamped with their collective authority. For his own part, speaking as an individual commissioner, he thought Mr. Wicksteed had exaggerated the difficulties of liquid manuring; and especially had laid undue stress on the supposed amount of pipeage that would be immediately necessary for carrying it into effect. He had described in his report successive circles of mains, amounting to 1200 miles in length, and costing, with engines and other adjuncts, between eleven and twelve millions sterling, to distribute the London sewage on above a million acres of land; and he argued, from this vast expenditure, and widely-extended range of distribution, that the plan was impracticable. But he (Mr. Ward) thought this resembled the arguments that were urged against gas-lighting at the outset. "What!" it was said in the old days of oil lamps, to the daring innovators who proposed gas-lighting, "do you seriously ask us to tear up all the streets of our towns, and lay down thousands of miles of subterranean arteries, to circulate a subtle vapour through every street, and into every house, to do at a cost of millions upon millions what our lamps and candles already do sufficiently well?" Such was the language used; and the proposal of gas-lighting was regarded, at the outset, by the majority of mankind, as the wildest and most visionary hallucination. But when Murdoch's factory had been illuminated with gas the whole problem was virtually solved; and when the first line of gas-lights burned along Pall Mall, the illumination of all the towns of Europe became a mere question of time. Just so, when the first farm had been successfully laid down with irrigating pipes for the distribution of liquid manure, there ceased to be any force in the argument about the quantity and cost of pipeage for this purpose; for what could be profitably done in 100 acres, could be done *a fortiori* on 1000 or on a 1,000,000. In this, as in other human affairs, progress would be gradual; there were not above one-fifth of the London houses in which cesspools were yet abolished, and as the water-closet system extended in the towns, so the means for utilising the refuse would, it might fairly be supposed, extend in the country.

Nor should we be deterred from grappling with the problem by contemplating the vast magnitude of the results to which it would lead in the course of time—of generations, perhaps, when the whole subsoil of Europe would probably be piped for the distribution of liquid manure, just as all Flanders was already honeycombed with tanks for its storage. Again, the recent decision which had been come to by the Commissioners as to the course of the main intercepting sewer on the south side, must not be supposed to imply that the Commissioners had settled the question what was to be done with the southern sewage, or on what plan it was proposed to turn it to account. The decision which had been arrived at was an engineering, not a chemical, nor an agricultural decision; it denied the necessity of a high level intercepting sewer as proposed by Mr. Bazalgette, and affirmed the sufficiency of a low level intercepting line, but further than that it did not go. So little, indeed, could the question how the refuse was to be dealt with be considered as settled in the opinion of the Commissioners, that while one part of the scheme of their own engineer contemplated carrying the sewage of forty square miles to Barking, another part of the same scheme (Mr. Bazalgette's) proposed turning the sewage of nineteen square miles, on the west side, into Battersea Reach, after treatment by some deodorising or precipitating process not as yet defined. He mentioned this in proof that the subject could not be regarded as settled, though he must say that he himself was strongly opposed to such a plan as that he had just referred to. His (Mr. Ward's) view, after careful inquiry, was adverse to the plan of precipitation, except in so far as it might be made available as a transitional expedient, while the *vis inertiae* of the farmers (always excepting such brilliant innovators as his friend, Mr. Mechi, opposite) was being gradually overcome; and, while the difficulties connected with the subdivision of property, and other obstacles of an administrative kind, were being dealt with. Adverting to Mr. Wicksteed's process itself, and generally to the processes in which lime was relied on as a precipitant, he said the defect of those processes could, he thought, be very shortly pointed out. Ammonia existed in sewage in two forms, one derived from the more solid *caput mortuum*, the other from the fluid residuum. The first form, or that in which the faecal ammonia occurred, was principally as undecomposed organic matter, the undigested excess of the aliment consumed; the other form, or that of the urine ammonia, was chiefly as urea, which, in the sewage, was speedily transformed into ammoniacal salts. Now the behaviour of lime was quite different towards ammonia in these two forms. One form, the organic fibre of the faecal residuum, lime sent down, the other, the ammonia of the salts derived from urine, it sent up; the first it precipitated mechanically, very much as white of egg clears coffee; the second it disengaged and set free as a volatile gas, substituting itself as a base in the salts decomposed. Now, if the organic fibre thrown down contained the larger part of the ammonia, Mr. Wicksteed's plan would be as useful in practice as it was ingenious and meritorious in conception. But, unfortunately, this was not the case. Four-fifths of the ammonia were derived from the urine, only one-fifth from the solid refuse. So that, to catch and retain, by means of lime, the faecal fifth, we were obliged to sacrifice the renal four-fifths. Such, at least, was his present impression, looking to the chemical principles involved, and to such facts as were as yet before them. He should be happy if Mr. Wicksteed could show him he was mistaken, and that means had been really discovered to make lime, detain the ammoniacal salts of sewage, as well as the undecomposed organic fibre. Until this could be shown, the lime process must be regarded as uneconomical in two senses; first, as wasting the larger part of the ammonia; secondly, as fixing in a very bulky form the small portion which it did throw down. On this latter point he would observe that, from the analyses which he had seen, it appeared

that, while good guano contained 15 or 16 per cent. of nitrogen, the lime precipitate of sewage would barely contain 3 per cent.; so that such a precipitate, in respect of cartage and distribution costs, was what a ton of guano would be if mixed with five tons of sand or other inert ingredient. On the whole he did not at present see reason to hope that this process would be available for the utilization of sewage, except, as he had before said, transitionally, while ulterior measures were in progress. On another point he entirely concurred in what had fallen from Mr. Lawes, than whom there was no man in this country to whom agriculture was more indebted for the admirable experiments which he had conducted on a princely scale for a series of years, and from which he had himself derived much instruction. He agreed with Mr. Lawes that the grand difficulty of dealing with the sewage of London consisted in its vast, and, above all, in its *variable* bulk. The average rainfall in London was about 24 inches, equal to about 2400 tons per acre. The area draining into the London sewers was 26,613 acres, or nearly 41½ square miles on the north side, 21 being central, 20½ suburban. The southern area was 18 miles, half central and half suburban as nearly as possible. Together, therefore, the London drainage area was 59½ square miles, central and suburban, in nearly equal proportions. A considerable portion of the rainfall on the suburban area was absorbed by the ground, but the greater part of that which fell on the paved surfaces of the central district, found its way to the sewers. Calculating from these data, and taking the water supply in round numbers at 50,000,000 gallons a day, it might be said that the total quantities of the rainfall and the sewage proper were nearly equal—about eighty or ninety million tons annually. But the difference was this, that while the sewage was produced uniformly day by day throughout the year, (increasing somewhat in summer, but still pretty uniformly), the rain, on the contrary, was so variable, that 2 inches or ¼th of the whole amount of annual rainfall, would sometimes fall on London in one hour. The weight of 2 inches of rain-fall was 7,621,516 tons., equal to more than a month's sewage. Even, supposing the rain to fall uniformly on the 152 rain-days, its amount would be 601,700 tons per rain-day—or three-times as much as that of the sewage (223,200 tons per day.) But of the total annual rain about 16 inches fell in 44 days; or two-thirds of this rain in about one-eighth of the whole number of days. This had been observed in an ordinary year, a little perhaps above the average humidity. On 30 days, ½ of an inch per diem fell; on 10 days, ¾ of an inch; on 2 days ¾ of an inch; and on 2 days 1 inch. On the quarter-inch days the rainfall was to the sewage as 4½ to 1, on the half-inch days as 9½ to 1, on the inch days as 19 to 1. Now, making all reasonable deductions for evaporation and absorption, it was obvious that these vast and sudden variations of bulk tended to make the sewage unmanageable. He had, therefore, given close attention to the question, whether these variations of bulk, which so complicated the agricultural part of the problem, might not be avoided; and, point by point, he had been brought to the conviction that, for the profitable utilisation of the sewage, as well as for the thorough interception of human refuse from the Thames, it is indispensable to separate the sewage from the rainfall. He was led to propound this principle—"The whole of the rainfall due to the river, the whole of the sewage due to the soil." Looking at it in the urban point of view, he said, "To dispollute the Thames you must, first of all, dispollute her tributary brooks that feed the Thames;" and, as it had been said, "take care of the pence, and the pounds will take care of themselves;" so he would say, purify your brooks, and your rivers will run pure of themselves. Looking at it in this agricultural point of view, he considered the sewers under London as guano mines, rendered un-

workable by flooding. The public, he considered, were the shareholders in these mines—the rates were calls that had been paid up, and the Commissioners were in the position of directors endeavouring to work the property up to a dividend-paying condition. The problem had hitherto baffled the ablest and most eminent engineers, including the engineer of the Commissioners, Mr. Bazalgette, whom he was glad to see present. They were attempting an impossibility in attempting to deal with streams liable to swell suddenly to several hundred times their ordinary bulk. The attempt to take such streams in enormous tunnels, like subterranean rivers, to Barking, was futile. The purification of the Thames could not be so accomplished. One day in twelve the rain-swollen brooks would still rush into the Thames, gorging and overflowing the biggest tunnels you could make, and carrying out tons of excrement into the tideway you were seeking to purify. And it was equally impossible, and equally uneconomical, to make culverts and reservoirs for the agricultural utilization of these swollen streams. He had been led, by these and similar considerations, to investigate the problem what it would cost to separate the sewage proper from the rainfall; to intercept the sewage water in twelve-inch pipes on its way from the houses to the sewers, instead of intercepting it with twelve-foot tunnels on its way from the sewers to the river. The inquiry was a laborious one, requiring an estimate of cost, street by street, and sewer by sewer, so variable were the conditions of the cases that presented themselves. But he had gone over a tract of the town, inhabited by upwards of 30,000 persons, more than one hundredth of the whole population, and he believed, from the results obtained so far, that the tubular would prove cheaper than the tunnel interception, independently of its superiority in facilitating the realisation of that which he regarded as an axiom in the modern sanitary art, namely, that "sewage, heretofore got rid of as refuse, must henceforth be administered as property." He said, in modern sanitary art, for the problem had originated in comparatively recent times. It had sprung out of Bramah's great invention of the water-closet, towards the close of the last century. Previously to the introduction of that admirable contrivance, which had secured us the inestimable benefit of cleanly defæcation, the refuse was retained in cesspools, and the sewers were protected by law from pollution. But the water-closet gave rise to a new requirement—that of an outfall for soil water—to which purpose the rain-sewers came gradually and illegally to be turned. This abuse made such slow and silent progress, as water-closets one by one came into use, that for a long time its importance had escaped attention; and the surreptitious pollution of the rain channels, originally connived at as insignificant, had come at last to be recognised as a system. The recent introduction of a cheap form of water-closet for the use of the working-classes, had given to this system such a sudden and rapid extension, that attention had at length been called to the monstrous proportions of the evil; which, plainly stated, was the annual discharge of many thousands of tons of putrifying excrement into the rain sewers, the brooks, and the river. Every step that we had made in this false direction must, in his opinion, be retraced. The dispollution of the river, the brooks, the rain sewers, constituted a chain of operations, the links of which were bound together by the logic of an irresistible necessity. This necessity might seem hard, but it was absolute. You could not divert in tunnels, nor master with pumps, half-a-dozen rain-swollen brooks: their flood waters must rush into the Thames, and must carry thither whatever excrement you had turned into their channels. He was, perhaps, however, dwelling too much on the urban aspect of the problem, on an occasion when they were specially considering its agricultural bearings. The two branches of the question were, however, intimately connected, and the main difficulties in both grew out of

one and the same fundamental error, namely, the pollution of the water brooks. He would say, in conclusion, dispollute the Ranelagh, the Fleet, and the other brook-sewers of London, and your main difficulties at once disappear; the purification of the river, and the utilisation of the sewage become comparatively easy matters. But so long as you go on discharging human excrement into the brooks (arched over, and now called valley line sewers), you are driven to adopt the Great Tunnel Scheme as a palliative measure, to diminish evils which it cannot cure; to reduce to about one day in ten or twelve (instead of reducing to zero) the number of rain-days during which excrement will be ponded among houses, or poured out into the river at low-water to go upstream with the flood; to lessen (instead of preventing) the accumulation of deposit in sewers by diminishing the intermittency of their out-flow, while retaining the insufficiency of their slope; and, in fine, to convey to the country, in a partially available condition, only so much of the sewage ammonia as may escape volatilisation by stagnancy, and dilution by rain. He thanked them for the indulgent hearing they had given him, and he trusted shortly to be in a position to submit the means of giving effect to his views in a practical shape for their consideration.

The CHAIRMAN said, when he looked at the time to which the clock before them pointed, he thought they would agree with him that it was pretty near the hour to wind up the business of the evening. They had had a most interesting, and he might say a most useful discussion; and he thought he should be wanting in his duty if he did not, in the name of the agricultural community, thank the Council of the Society of Arts for giving them the opportunity of hearing the admirable paper which had that night been read to them by Mr. Lawes; and also the very instructive discussion which they had heard from other gentlemen who seemed well up in the subject, and well acquainted with what they were speaking of. What was most satisfactory to his mind was, that no two opinions seemed entirely to agree, because, so long as the scientific men whom they had heard that night differed in opinion, it would be the interest of every man of common sense, and with brains in his head, to work out the subject for himself; at the same time, he hoped in the end they would come to something like a definite result. There was, however, one subject mentioned by Mr. Chadwick which, if allowed to pass unnoticed, might convey an erroneous impression to the minds of many present. Mr. Chadwick had stated that water companies made a considerable profit by sending a ton of water ten or twelve miles off at 2½d. per ton, but Mr. Chadwick forgot—or at least he did not put it in that form—that where the water was sent in that way there were a vast number of houses that contributed to the main channel which carried the water to a certain point. Mr. Chadwick could not have lost sight of this consideration in his calculation of the cost of supplying manure, but he did not bring it forward in his explanation; consequently it did not follow that, because a water company could deliver water at Brentford (for example) for 2½d. per ton, a gentleman having a farm the same distance off could get his sewage water at the same rate. If they could get a vast quantity of land lying together, and a certain number of persons subscribed to have the same conduit, then it would be an easy matter to have small conduits to their own farms. With these few remarks he would beg the meeting to join with him (and he was sure all he saw around him would readily do so) in returning the thanks of this Society to Mr. Lawes, for the very able and very instructive paper which he had read to them that night.

The vote of thanks having been unanimously passed,

The Secretary announced that the Paper to be read at the meeting of Wednesday next, the 14th inst., would be, "On a New Method of Teaching Drawing, involving the Principle of

a New System of Architecture." By Herr Joseph Kumpa, of Dresden.

* * It having been represented, after the meeting, that there were still many gentlemen who were anxious to make some remarks on the important subject of the "Sewage of London," the Secretary is authorised to state that an Extraordinary Meeting has been fixed for Monday, the 19th inst., at eight p.m., for the purpose of renewing the Discussion.

INSTITUTE BOOK ORDERS.

FEBRUARY ACCOUNT.

	Full Price.			Red. Price.		
	£	s.	d.	£	s.	d.
Aylesbury, Mechanics' Institution	6	15	9	5	8	4
Blairgowrie and Rattray Mechanics' Institute	5	0	0	3	11	5
Brighton, Railway Literary and Scientific Institution	0	5	0	0	3	7
Bristol, Athenæum	21	12	1	16	3	9
Bury, Athenæum	6	0	0	3	15	8
Cambridge, Philo-Union Society	5	3	0	3	18	7
East Retford, Literary and Scientific Institution	0	15	0	0	11	9
Hampton (Middlesex), Literary Society	3	17	6	2	15	9
Horncastle, Mechanics' Institution	11	15	6	8	15	0
Leven (Vale of), Mechanics' Institution	19	2	4	14	6	1
London, Bank of England Library and Literary Association	8	2	10	6	9	8
Middlesbro', Mechanics' Institute	3	19	6	3	2	9
Northallerton, Institute	1	19	6	1	9	5
Northampton, Religious and Useful Knowledge Society	10	12	0	8	2	6
Sevenoaks, Literary & Scientific Institution	7	8	0	5	14	11
Sheerness, Isle of Sheppy Mechanics' Institution	1	8	0	1	9	6
Stamford, Institution	1	1	5	0	17	0
Tiverton, Literary and Scientific Institution	3	7	0	2	11	6
Yarmouth (Great), Institute	4	15	8	3	10	5
	£123	0	1	£92	17	7

Being a saving of £30 2s. 6d., or about 25 per cent.

INTERNATIONAL COMMERCIAL LAW—BILLS OF EXCHANGE.

A letter, of which the following is a copy, has just been addressed to the Solicitor General by Mr. Leoni Levi.

"The Law of Bills of Exchange is about to be altered with regard to diligence or execution for the enforcement of payment, and the time seems propitious for endeavouring to introduce any other improvement which may render this instrument free from difficulty. The days of grace have always proved a source of much inconvenience, from the difference of the practice or custom in many places and states. France has abolished them by the Code Napoleon, and also all other nations which have adopted the same code. By the law of Bills of Exchange lately passed in Germany, days of grace were abolished throughout the German States, and it seems to me that it would be highly advisable to abolish the three

days of grace as they are allowed in this country, so as to put our law on the subject on an equal footing with that of other European nations. In the event of such a change being effected, it may be also considered whether, were bills become due on Sundays and holidays, and are now payable on the days previous, they ought not to become payable on the following day, an alteration which, where bills are becoming due on Sundays, and payable on Saturdays, would facilitate the desire generally felt of diminishing business on Saturdays."

Home Correspondence.

THE DISCUSSION AS TO WATER SUPPLY.

SIR,—I neither had, nor have I, any intention of engaging in a controversy with Mr. Homersham, but as he has thought fit to put forth in your pages a representation and account of the Dalton gauge in use at Apsley mill, which I had twice assured him to be false, I am reluctantly compelled again to address you.

The gauge in question was constructed some twenty years ago, not for the purpose of being employed in antagonism to such schemes as those of Mr. Homersham, but to enable Mr. Dickinson to form an approximate estimate, in the spring of the year, of the supply of water that would be available for his mills during the ensuing summer and autumn.

As the simplest and best means of ascertaining and placing beyond doubt the nature of the soil with which the receiving cylinder of the gauge was filled, I have this day had it emptied, and find that, as I had already stated, there was no peat among its contents, and that the section at p. 245 of your Journal, is as entirely erroneous as many other of Mr. Homersham's so-called facts. The upper 10 inches consisted of mould and the ordinary surface soil of the neighbourhood, completely riddled with worm holes; beneath this was a layer of about 15 inches of sandy gravel, getting gradually coarser as it approached the bottom, which was filled with coarse gravel, entirely free from clay or sand. The water that percolated through this was collected in a leaden saucer-shaped vessel, that extended to the outside of the wooden tube, from which vessel it was conducted by a leaden pipe to the graduated gauge. As the percolating water would, by its own gravity, descend in a direction as nearly as possible perpendicular, I conceive that the gauge would indicate nearly the same results, even if the wooden tube were entirely removed. When the gauge was first erected, the overflow-pipe was carefully watched, but it was found in practice that no overflow whatever took place, the soil being sufficiently porous to absorb the heaviest rains that fell.

Taking an impartial view of the contents of the receiving cylinder of this gauge, I am of opinion that if its results are in any way erroneous, it is in showing an amount of percolation larger than would actually take place over any extended area of this district, as it is very rarely that a section of three feet from the surface of the ground would present so permeable a series of beds.

I had the less reluctance to distrust this gauge, as we have had one of a similar character, but of cast iron, and on a larger scale, in operation during the last two years.

As regards our pumping, for the purposes of our manufacture, large quantities of water from wells and bore-holes sunk in the chalk, it is perfectly true that such is the case, though not to the extent asserted by Mr. Homersham. The quantity of water obtainable from wells and bore-holes sunk in the chalk and many other strata, depends, within certain limits, on the number and size of the fissures intersected, and as from common opinion, and our own experience at Manchester in 1834, we were led to believe that the cheapest and best manner of laying open the necessary extent of fissures was by boring, we em-

ployed Mr. Paten, a neighbouring well-sinker, for this purpose.

I am quite willing to admit that, whatever amount of water we may pump from these wells and bore-holes, is so much abstracted from the reservoir supplying the springs and rivers of this district, but as, after using it, we return the whole of what we pump to the river, we cannot see that we injure our neighbours in any way, or what particular private advantage we can be said to derive from having employed Mr. Paten in preference to any other well-sinker.

At all events we cannot be classed with those who would rob the inhabitants of these valleys of their water, and then claim to be considered public benefactors for selling the stolen property at a high price in London.

I am, sir,

Your obedient servant,

JOHN EVANS.

Nash Mill, Hemel Hempsted, Feb. 26, 1855.

Proceedings of Institutions.

BEDFORD.—On Wednesday, the 28th ult., the Rev. Thomas W. Aveling, of London, gave a very interesting lecture on "Jerusalem and its Environs." Dr. T. H. Barker, V.P., occupied the chair, and, at the close of the lecture, tendered the warmest thanks of the committee and of the audience to the rev. gentleman, for his great kindness in coming down to give them such a graphic account of the scenes and places he had visited during his recent tour in the east.

COWPAR ANGUS.—The twentieth anniversary of the Mutual Improvement Society was celebrated, in the Meeting Room, Campbell-street, on the evening of Tuesday, the 27th ult., Mr. D. Don in the chair. The balance-sheet showed that, although the Society is almost solely composed of, and supported by, a handful of poor working men, it has a mass of valuable property free from debt, and a small balance in the hands of its treasurer. There were no set speeches, but Messrs. Ferguson, Wilson, Forbes, Stewart, Robertson, and Mill, carried on an instructive conversational discussion on various important subjects, but more especially on mine-ralogy, and social economy. The table was well furnished with refreshments (no ardent spirits), which were freely partaken of during the evening. The proper work of the anniversary being ended, it was resolved to continue the important connection with the Society of Arts, and to petition the House of Commons to purchase the valuable collection of works of Art which belonged to the late Ralph Bernal, Esq., M.P.

MEETINGS FOR THE ENSUING WEEK.

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| MON. | Geographical, 8½. |
| TUES. | Royal Inst., 3. Prof. Tyndall, "On Electricity." |
| | Syro-Egyptian, 7½. 1. "Dr. J. Lee, "On Some Maltese Coins." 2. Mr. Marsden, "On a Sarcophagus of the Reign of Hophra." 3. Mr. Bonomi, "On the Birs-i-Nirrud." |
| | Civil Engineers, 8. Mr. R. A. Robinson, "On the Application of the Screw Propeller to the Larger Class of Sailing Vessels." |
| | Med. and Chirurg., 8½. |
| | Geological, 9. |
| WED. | Society of Arts, 8. Herr Joseph Kump, "On a New Method of Teaching Drawing, involving the Principle of a Natural System of Architecture." |
| | Graphic, 8. |
| | Ethnological, 8½. |
| | Royal Soc. Literature, 8½. |
| THURS. | Royal Inst. 3. Mr. Donne, "On English Literature." |
| | Statistical, 3. Anniversary. |
| | Antiquaries, 8. |
| | Royal, 8½. |
| FRI. | Royal Inst. 8½. Dr. William Odling, "On the Chemistry of the Hydro-Carbons." |
| SAT. | Royal Inst. 3. Dr. Gladstone, "On the Principles of Chemistry." |
| | Medical, 8. |

PARLIAMENTARY REPORTS.

SESSIONAL PRINTED PAPERS.

Par. No.

Delivered on 1st March, 1855.

77. Assistant Surgeons (India)—Copy of Regulations.
81. Committee of Selection—2nd Report.
22. Bills—Court of Chancery (Ireland) (Jurisdiction).
34. Bills—Court of Chancery (Ireland) (Receivers).
37. Bills—Court of Chancery (Ireland) (Stamp Duties).
39. Bills—Tenants' Improvements Compensation (Ireland).
45. Bills—Ecclesiastical Courts.
Tuscany (Coasting Trade)—Convention.

Delivered on 2nd March, 1855.

73. Court of Chancery—Return.
79. Tallow, &c.—Return.
86. Army before Sebastopol—1st Report from Committee.
87. Committee of Selection—3rd Report.
46. Bill—Purchasers Protection against Judgments.
Railways—Reports upon certain Accidents (Nov. and Dec. 1854).

Delivered on 3rd and 5th March, 1855.

- 65 (1). Trade and Navigation Accounts.
80. Queen Anne's Bounty—Account.
84. Education (Ireland)—Return.
47. Bills—Union of Benefices.
49. Bills—Secretaries and Under Secretaries of State (House of Commons).
50. Bills—Tea Duties Decline Suspension.
France (Supplies to be furnished to the Turkish Army)—Convention.
France (Electric Telegraph between Bucharest and Varna)—Convention.

Delivered on 6th March, 1855.

50. Bill—Ecclesiastical Property (Ireland).

Delivered on 7th March, 1855.

67. Highways—Return.
83. Newspaper Stamps—Return.
90. Voters (Ireland)—Abstract of Return.
92. Commissariat—Estimate.

PATENT LAW AMENDMENT ACT, 1852.

APPLICATIONS FOR PATENTS AND PROTECTION ALLOWED.

*[From Gazette, March 2nd, 1855.]**Dated 13th January, 1855.*

92. J. Britten, Birmingham—Filtering liquids.

Dated 24th January, 1855.

182. J. Livesey, New Linton—Lace machinery.

Dated 3rd February, 1855.

254. P. M. Crane, Attry, Kildare—Products from peat.

Dated 12th February, 1855.

322. J. Ramsbottom, Longsight, near Manchester—Metallic pistons.
324. G. Lucas, Hulme, Manchester—Spinning machinery.
326. R. Kerr, 41, Coleman-street—Loaf sugar.
328. J. Foster, Long Eaton—Lace machinery.

Dated 13th February, 1855.

330. J. L. Lambot, Carces, Var—Building material as a substitute for wood.
332. R. P. Courfield, Upper Holloway—Electro-coating of iron, &c. (Partly a communication.)

Dated 14th February, 1855.

334. T. Metcalfe, W. Slaiding, and J. Metcalfe, Clitheroe—Dyer's tube-frames.
336. I. R. Isaac, Liverpool—Portable buildings.
338. H. L. Pattinson, jun., Newcastle-upon-Tyne—Iron carriage-wheels.

Dated 15th February, 1855.

340. W. Blythe, Oswaldtwistle, and E. Kopp, Accrington—Soda-ash, and sulphuric acid.
342. J. Leadbetter, Halifax—Railway breaks.
344. J. Mason and S. Thornton, Rochdale, and T. S. Sawyer, Longsight—Finishing yarns.
346. C. F. Delabarre, Paris—Apparatus for propelling gases and forcing liquids.

Dated 16th February, 1855.

348. E. Carless, Steney—Paper cloth, or artificial leather.
350. W. C. S. Percy and W. Craven, Manchester—Bricks, tiles, pipes, &c.
352. H. L. Pattinson, jun., Newcastle-upon-Tyne—Wrought-iron tubes.
354. R. Blackburn and W. L. Duncan, Wandsworth—Bleaching.

- [356. A. H. Ward, jun., Massachusetts—Loom temple. (A communication.)

Dated 17th February, 1855.

360. J. Hackett, Derby—Leather cloth.
362. J. Robb and L. Hill, Greenock—Masts and spars.

Dated 19th February, 1855.

364. G. R. Chittenden, London—Measuring fluids. (A communication.)

WEEKLY LIST OF PATENTS SEALED.

Sealed March 2nd, 1855.

1942. John Henry Pape, Paris—Improvements in wind musical instruments.
1951. Paul Adolphe Garnaud, Paris—Improvements in certain gazo-gene apparatus used for the production of aerated liquids.
1957. John Youll, Burton-upon Trent—Improvements in the mode or method of fermenting liquors, and in the machinery or apparatus employed therein.
1960. Tony Petitjean, 45, Upper John-street, Fitzroy-square—An improved process for re-cutting or re-forming the faces of files.
1963. William Prior Sharp and William Weild, Manchester—Improvements in the production of raw and thrown silk, and in machinery and apparatus to be used for the purpose.
1985. Charles Wentworth Forbes, Bartley, Hants—An improved rest for fire-arms.
1996. Charles Frederick Stansbury, 17, Cornhill—Improved machinery for making screws.
1998. Charles Frederick Stansbury, 17, Cornhill—Improvements in punches and dies.
2022. Joseph Porter, Salford Screw Bolt Works, near Manchester—Improvements in machinery for cutting, punching, forging, and forming nuts, bolts, screws, and various other articles in metal.
2026. Martin Billing, and Walter George Whitehead, Birmingham—A new or improved waterproof paper.
2046. Thomas Lawrence, Birmingham—Improvements in machinery or apparatus to be employed for the purpose of shaping and finishing certain parts of bayonets.
2050. Thomas Garnett, Liverpool—Improvements in steam-engine and other governors.
2052. Thomas Banks, Derby, and Henry Banks, Wednesbury—Improvements in apparatus for retarding and stopping railway trains.
2092. Thomas Foxall Griffiths, Birmingham—An improvement or improvements in lamps.
2093. Thomas Mohan, Aclint, Louth—An improved churn.
2498. Peter Armand le Comte de Fontaine Moreau, 4, South-street, Finsbury—Improvements in the manufacture of wrought-iron wheels for locomotives or railway or other carriages. (A communication.)
2666. Louis Henri Frederic Melsens, Brussels—Improved process of saponification.
2687. George Tomlinson Bousfield, Sussex-place, Loughborough-road, Brixton—Improvements in machinery for splitting leather.
2694. Henry Render, Liverpool—Improvements in the manufacture of night lights.
Sealed March 6th, 1855.
1970. Achille Guyardin, Paris—The use of a certain fibrous matter for the manufacture of paper and pasteboard.
1976. John Rigby, Dublin—Improvements in fire-arms and guns, and in waddings to be used therewith.
1977. Edward Palmer, Southampton—Improvements in propelling vessels.
1981. John Chilcott Purnelle, Tachbrook-street, Pimlico—Improvements in obtaining and applying motive power.
1983. Edward Gillman, Twickenham—Obtaining filaments from certain vegetable substances, and applying the same to various manufacturing purposes.
1997. Charles Frederick Stansbury, 17, Cornhill—Machinery for making lock springs.
2003. Thomas Purdon, Hull—Improvements in safety lamps.
2004. Robert Rawlinson, Westminster—Improvements in valves or adjustable thoroughfares.
2033. Auguste Edouard Loradoux Bellford, 16, Castle-street, Holborn—Improvements in machinery for washing paper stock.
2039. William Prior Sharp and William Weild, Manchester—Improvements in machinery for winding, cleaning, doubling, spinning, and throwing of silk.
2057. Georges Danré, Marseilles—Improvements in gas-burners.
2079. Robert Renfrew, Glasgow—Improvements in bobbins.
2420. Frederick Joseph Bramwell, 29, New Bridge-street, Blackfriars—Improvements in steam engines and steam hammers.
9. Joseph Arnold, Tamworth—A new mode of ornamenting bricks and other moulded articles for building purposes.
112. George Jackson, Manchester—Improvements in the construction of tents.

WEEKLY LIST OF DESIGNS FOR ARTICLES OF UTILITY REGISTERED.

No. in the Register.	Date of Registration.	Title.	Proprietors' Name.	Address.
3690	March 2.	Radiating Gas Stove	J. Rhodes and Co.	Holborn Brass Foundry, Nottingham
3691	,, 3.	Stays or Corsets	William Piyer Elby	Portsea.